

LUND INSTITUTE OF TECHNOLOGY

TRANSPORTATION AND MATERIALS HANDLING
ENGINEERING DEPARTMENT



ANALYSING, PLANNING AND SELECTION OF MATERIALS HANDLING SYSTEMS
IN A COUNTRY ON THE WAY TOWARDS INDUSTRIALIZATION

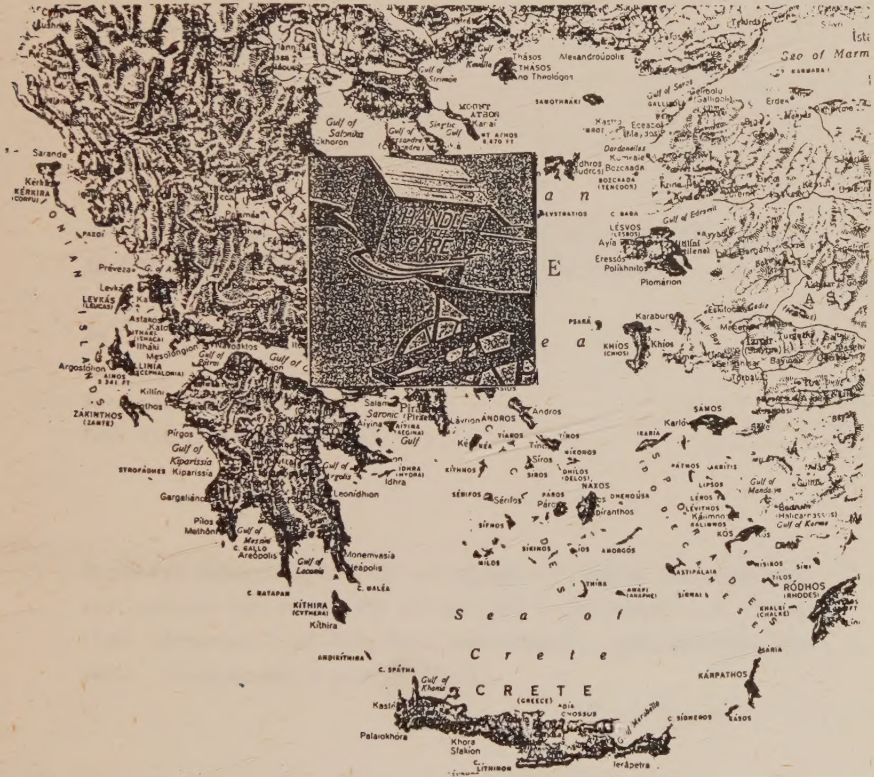
PARASCHOS MANIATIS

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ANALYSING, PLANNING AND SELECTION OF MATERIALS HANDLING SYSTEMS
IN A COUNTRY ON THE WAY TOWARDS INDUSTRIALIZATION

Av

Paraschos Maniatis

Tekn lic (Smålands nation)

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Abstract Introducing materials handling systems abroad involves among other things an introduction of special factors and other inputs into the receiving country, e.g. capital, workers, raw material, produced goods, technical know-how as well as knowledge of management and marketing. It is difficult to introduce materials handling systems in countries that do not have enough capacity to receive and absorb technological information. Greece today can be considered a country on the way towards industrialization. Industrialization is primarily carried out through large foreign companies and the Greek enterprises. In Greece there hardly exists any technique for analysing, planning and selection of materials handling systems, and no education is carried out in this field. The existing methods practised in industrial countries do not completely cover the needs of the Greek industries. The aim of this research project is to investigate the factors which aim to form a basis of materials handling analysis, planning and selection of materials handling systems in a country on the way towards industrialization (Greece), and to specify a method of planning. The method specified by the author is divided into seventeen working steps. A classification of the method used to assist in the selection of an optimum materials handling system is: general advice and instruction, check lists, decision model, and selection with the help of computer technics, operation analysis, simulation models, and trends (escalation, mechanization, regard to the work environment, standardization, centralization, utilization of computers and increased co-operation).	
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Date 1983-03-22


Ithaka has given you your lovely journey.
Without Ithaka you would not have set out.
Ithaka has no more to give you now.

Poor though you find it, Ithaka has not cheated you.
Wise as you have become, with all your experiences
You will have understood the meaning of an Ithaka.

by C.P. Cavafy

Translated by
G. Valassopoulos

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PREFACE

This doctor's dissertation entitled Analysing, Planning and Selection of Materials Handling Systems in a Country on the way towards Industrialization, has been worked out at the Transportation and Materials Handling Engineering Department of Lund's Institute of Technology.

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Finally, I'd like to thank the prominent pioneer and researcher in this field, Dr. Richard Muther, visiting professor at the Transportation and Materials Handling Engineering Department, Lund Institute of Technology, for the thorough discussions we had about the project.

Lund, February 1983
Paraschos Maniatis

SUMMARY

Introducing materials handling systems abroad involves among other things an introduction of special factors and other inputs into the receiving country, for example capital, workers, raw material, produced goods, technical know-how as well as a knowledge of management and marketing. It is difficult to introduce materials handling systems in countries that do not have enough capacity to receive and absorb technological information. Many of the technologies exploited today in the most advanced industrialized countries are in general not directly applicable to developing countries which have completely other needs and structures. Exploitation of industrial technology in a mainly agrarian society can for example lead to heavy distortions in exploitation of factors and resource allocation.

Greece today can be considered a country on the way towards industrialization. Industrialization is primarily achieved through large foreign companies and the Greek enterprises. On the other hand, there is no general industrial milieu and experience to support the growth of private Greek companies.

The purpose of the research project is to investigate the factors which aim to form a basis of materials handling analysis, planning and selection of materials handling systems in a country on the way towards industrialization (Greece). The aim of the research project is also to increase the knowledge of factors which influence the selection of the level of mechanization of materials handling systems.

The investigation includes interviews and discussions with representatives, consulting firms and authorities, visits to a number of Greek industries, private and literature studies of the author, own analytical and development work, Doctor's seminars and report writing.

In Greece there hardly exists any technique for analysing, planning and selection of materials handling systems, and no education is given in this field. Engineers in industry continue to accept the existing materials handling systems, as they do not have the appropriate knowledge to modify or improve them. Industries and consulting firms in Greece feel the need for a complete method for analysing, planning and selection of materials handling systems which should cover the industrial need and not only be of a theoretical character.

The existing methods which are applied in the industrial countries do not completely cover the needs of the Greek industries. The method specified by the author is divided into seventeen working steps. In the first steps you will obtain the data and information needed to carry out the demand analysis. In working step 15) you will obtain a number of alternative materials handling systems which will be evaluated in the step 16). The final selection of an alternative will be made in the step 17).

The method is applicable to both big and small, simple and complicated materials handling systems. Furthermore, you can use it independently for a new system or for alteration of an old one.

To optimize a materials handling system we must not forget to put the problem into its connection, that means to give consideration to the whole chain from suppliers via factory up to the ultimate consumer. A classification of the method used to assist in the selection of an optimum materials handling system is:

General advice and instruction, check lists, decision model, and selection with the help of computer technics, operations analysis, simulation models, and trends (standardization, centralization, utilization of computer, increased co-operation, and regard to the work environment).

1. INTRODUCTION

"The history of materials handling is as old as that of civilized man himself. As soon as men began to live and work in settled communities and trade developed, problems of handling materials were encountered.

It was not, however, until the Industrial Revolution brought the development of mechanical power and of prime movers that a tremendous stimulus to mechanical invention introduced Materials Handling as we know it today. The canal and railway systems testify to the intense demand felt at this period to make transportation and communications keep up with the rapidly developing manufacturing potential. In industry, a trend to greater specialization accelerated the growing demand for the movement of material.

The application of machinery to production processes since the industrial revolution has been exploited to the full; it has, however, led to manufacturing techniques which placed too great an emphasis upon "floor to floor" time. Until fairly recently, labour was still comparatively cheap, and substantial gains in productivity were constantly being achieved; but there was a lack of appreciation of the contrast between the inefficient and uneconomical methods being used for moving material and the increasing productivity of the power-driven production machinery." (Booth & Chantrill 1962).

During the last two decades there has been a change of emphasis in the planning of manufacturing methods. The growing cost and shortage of labour, the increasing cost and volume of goods, together with rapid changes in style or design of products have encouraged manufacturers to apply the mechanized techniques and rational planning, so successfully applied to production processes, to the handling of materials.

Introducing materials handling systems abroad involves among other things an introduction of special factors and other inputs into the receiving country, for example capital, workers, raw material, produced goods, technical know-how as well as knowledge of management and marketing. It is difficult to introduce materials handling systems to countries that do not have enough capacity to receive and absorb technological information. This is especially valid for developing countries (Solo 1967), but also applies to a great number of countries that have not yet built up an independent industry with a high level of knowledge, significant elements of research and development and a comprehensive industrial infrastructure (e.g. Greece, Spain, Portugal and S. Italy). Whereas, advanced industrialized countries normally have the capacity to receive and adapt the technology for their own use. Thus, the introduction into these countries does not create as big a problem as the introduction into countries that are without capacity in the form of industrial experience, active research and development, fundamental research etc.

2. PROJECT'S PLAN

2.1 Purpose

The aim of the research project to begin with is to investigate factors which influence the selection of materials handling systems for industries in a country on the way towards industrialization. These factors aim to form a basis for materials handling analysis, planning and selection of materials handling systems. With the help of these factors the following advantages, among others, are achieved.

- a) Better solutions to materials handling systems
- b) Cost savings in the total process of production
- c) More rational handling
- d) Greater respect to factors which can't be measured directly in form of costs and income, for instance work environment, manufacturing capacity, speed of materials flow, flexibility, safety and coordination between functions of materials handling and other functions in an industry.

The purpose of the research project is also to increase the knowledge of factors which influence the selection of the level of mechanization of materials handling systems. The selection of this level has already been the subject of certain studies in connection with transport planning. (Larsson 1973).

2.2 Limits of the study

A. The present study is limited to the following productive activities:

- receiving the raw material
- processing
- forming
- machining and
- assembly

The packaging, storage/warehousing and shipping activities are not analysed in this study.

- B. Quantitative techniques for analysing materials flow are not analysed in the present study.
- C. Procedures for step-by-step planning in any layout project are referred to but the factors, considerations, physical features which are necessary in applying the various steps in action, are not dealt with in this study.
- D. Conventions for identifying, visualizing, and rating the various activities, relationships, and alternatives involved in any layout project are not dealt with in this study.

2.3 Working Methodology

Two pre-projects - "Investigation of the materials handling system in a Greek tannery" (Maniatis 1981) and "A literature study of materials handling analysis and layout planning" (Maniatis 1982a) - have provided a basis for estimation of the need of research; and a third pre-project - "Planning materials handling systems in Greek industries. Important factors." (Maniatis 1982b) - has given the requisite background material for formulation of the title of the dissertation:

"Analysing, Planning and Selection of Materials Handling Systems in a Country on the Way towards Industrialization".

Pre-project 1 - Investigation of the materials handling system in a Greek tannery

This was an initial effort to investigate how and to which extent systematic handling analysis and systematic layout planning can be applied to a Greek industry.

The result of the investigation was documented and introduced at the Transportation and materials handling engineering department, LTH. CODEN: LUTMDN/(TMTP-3060)/(1981).

Pre-project 2 - A literature study of materials handling analysis and layout planning

This was an effort to present and discuss in an analytical way all the stages and the various phases of the systematic handling analysis (SHA) and the systematic layout planning (SLP). The result of a data-searching at the Lund University's Library 2 in September 14, 1981, has shown that the SHA and the SLP are the unique existing complete methods. The literature that has been received from the data-searching gives us various modifications, advanced methods or another way to develop and discuss the stages and the phases of the above methods.

The result of the data-searching was documented and presented at the Transportation and materials handling engineering department, LTH. CODEN:LUTMDN/(TMTP-3063)/(1982).

Pre-project 3 - Planning materials handling systems in Greek industries. Important factors.

After visits to and discussions at some Greek companies, as well as discussions with consulting firms, associations and authorities, suggestions for an investigation could be presented.

The purpose of this pre-project was:

- to present working steps for planning materials handling systems
- to present factors which must be taken into consideration when planning materials handling systems in Greek industries
- to give the necessary knowledge for applying the various working steps.

When choosing appropriate objects of study, the following criteria were taken into consideration:

- the geographical position of the industry
- type of manufacture
- the appearance of the industrial area
- materials handling systems of interest for the investigation.

The following industries were considered interesting for the investigation:

- a) A company manufacturing household apparatus, ELCO-VAYIONIS
- b) Foundry of KONSTANTINOS DIMOU
- c) PERFIL. S. PROUSALOGLOU & YIOS A.E
- d) VIVECHROM A.E.

Because of limited means, field studies were only carried out at the industries a) and b).

The result of the field studies was documented and presented at the Transportation and materials handling engineering department, LTH. CODEN:LUTMDN/(TMTP-3068)/(1982).

MAIN PROJECT: ANALYSING, PLANNING AND SELECTION OF MATERIALS HANDLING SYSTEMS IN A COUNTRY ON THE WAY TOWARDS INDUSTRIALIZATION.

In the first step the introduction and project plan of the doctor's dissertation are determined. In the subsequent analysis and definition part I take up essential nomenclature questions.

The aim of the materials handling system is mentioned in a special chapter.

I have given regard to the analysis of existing methods, the analysis of requirements and I have tested the existing methods according to analysis of requirements: own analytical and development work is introduced and analysed, accordingly, the result of the field studies.

I then make suggestions for guiding principles of development. These suggestions even involve initiation of a number of research projects.

The main project has been documented through this dissertation. The applied working methodology can be summarized according to Figure 1.

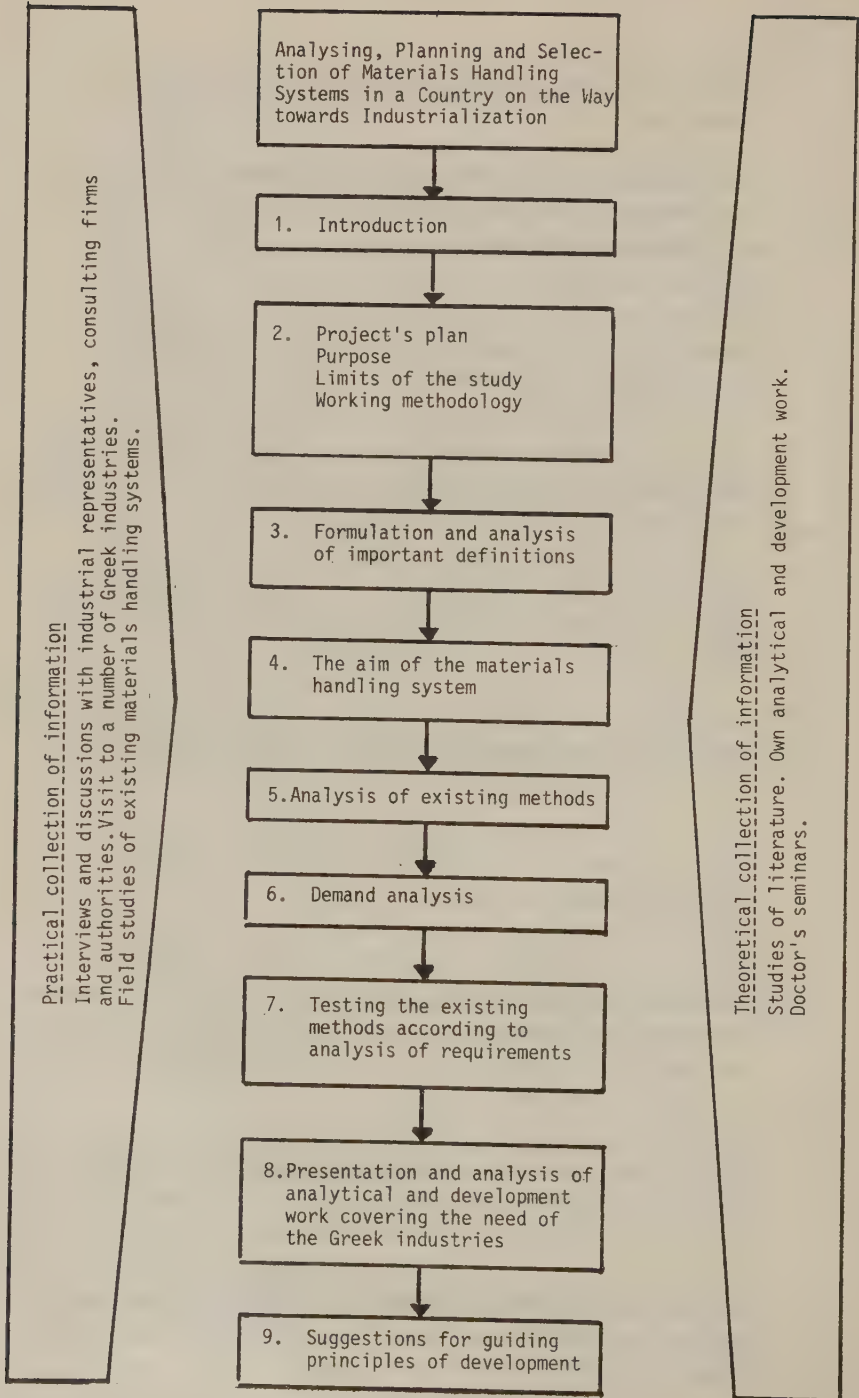


Figure 1. Doctor's dissertation disposition.

The following research activities have to a varying degree been adapted to the different parts of the project:

- a) Interviews and discussions with industrial representatives, consulting firms and authorities. Visits to a number of Greek industries.
- b) Private and literature studies of the author (Maniatis 1982a).
- c) Own analytical and development work. Field studies of existing systems at a foundry and a mechanical workshop (Maniatis 1982b).
- d) Doctor's seminars (presentation, discussion and critical examination of research results).
- e) Report writing.

3. FORMULATION AND ANALYSIS OF IMPORTANT DEFINITIONS

3.1 Nomenclature, definitions, and symbols

A simple definition of materials handling has been expressed as "Materials handling is the lifting, shifting, and placing of any material, regardless of its size, form, and weight".

The following definition gives a more comprehensive assessment:

"Materials handling is that field dealing with the analysis of problems of movement, packaging, and transport of material, with the design, selection, and operation of equipment to solve these problems, and with the recruitment and training of materials handling personnel."

In connection with materials handling the following terms and definitions are also used:

Systematic Handling Analysis (SHA) is an organized, systematic approach to analysing materials handling problems.

Systematic Layout Planning (SLP) is an organized, universal approach to any layout-planning project.

System is a specific type of equipment, working with a specific type of transport unit making a pattern of moves.

Method is a certain system, equipment, and transport unit.

Transport unit is an individual item, unit load, container, support, or even attachment.

Plan is a combination of different methods which have been planned for integrated operations.

Figure 2 shows six symbols, normally used in systematic handling analysis.

Symbol	Activity or Action
	OPERATION
	TRANSPOR- TATION
	HANDLING
	INSPECTION
	STORAGE
	DELAY

Figure 2. Process chart symbols.

A transportation occurs when an object is moved from one place to another, except when such movements are considered as a handling or as a part of an operation or inspection at a work station.

A handling occurs when an object is arranged or is prepared for another action (operation, transportation, handling, inspection, storage or delay).

3.2 Materials handling system

"Materials handling system" is often used as a well-defined and relatively plain definition. On closer study however, the word

can be allotted different significations depending upon in which connection it is used, and by whom.

It is difficult to give the term "system" a definition that is broad enough to cover the many fields of application and at the same time concise enough to serve a useful purpose.

One way to define materials handling system generally is to regard it as a number of components related to each other and to a purpose.

Three different types of components can then be distinguished:

- materials flow components
- operative components
- relation components (structural components).

Materials flow components mean the components to be moved and handled within and by the system. They are mainly made by products in different tooling stages, for instance raw material, semi-finished products and finished products, and also by load carriers, for instance pallets, wagon-bridges and containers.

Those components which cause moves and materials handling components are called operative components. Means of movement equipment, loading and unloading places and the physical part of an operative control system are examples of such components.

Components which have the main function to maintain necessary relations between other components are called relation components. Transport routes, transport organization, instructions and communications are examples of such components.

A materials handling system can be regarded as an input-output-system where the components described make input in the system. Figure 3.

A system's environment can simply be defined as all the components which are not a part of the system but in some way influence or are influenced by it.

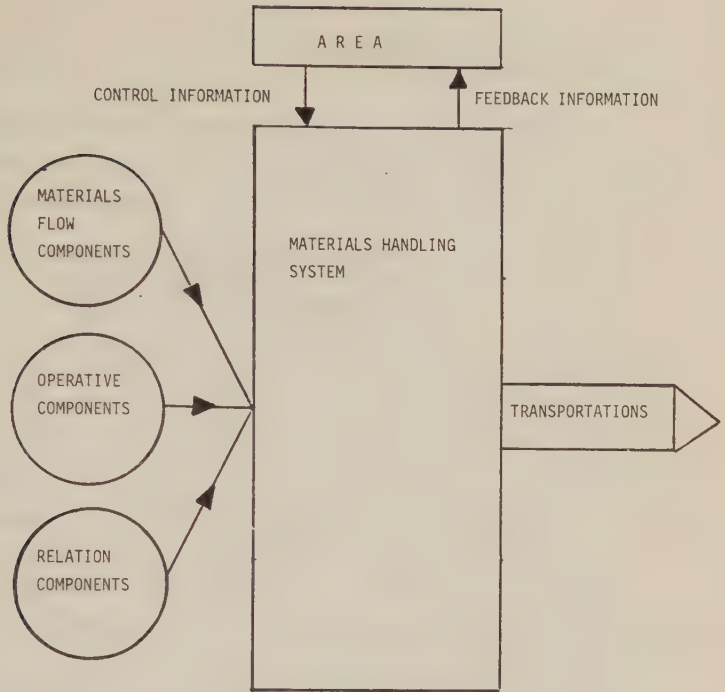


Figure 3. A materials handling system as an input-output system.

Between the materials handling system and its environment there is control and feedback information. The relation between the components of the system and its purpose is, as defined generally, effected with the help of this control. A purpose can for instance be expressed as follows:

- to establish a definite service level at the lowest possible cost.

A materials handling and transportation system may be a very complex unit with many different parts and relations which have a component purpose. A certain system can be regarded as a component in another. We can speak about systems on different levels,

systems and subsystems. Figure 4.

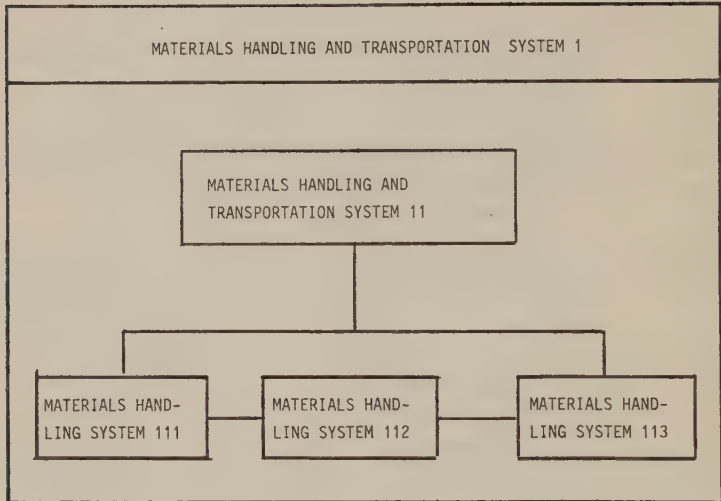


Figure 4. Materials handling and transportation system with belonging subsystems.

3.2.1 Relations between components

There are many different relations between the components of a system. They vary from case to case. Some examples of usual types of relations are:

- Methods, routines, experiences that are the way in which transports are generally carried out
- Laws, orders, agreements (for instance concerning wage and employment conditions)
- Working instructions (concerning performance of transports)
- Operating instructions for transportation equipment
- Formal and informal organization of transport work

- Communication and information within and between personnel groups
- Education, courses
- Competition
- Service level
- Quantity and capacity conditions
- Accident risks (for personnel and goods)
- Ergonomic aspects
- Methods of calculation, measuring and estimating
- Relations of time and order, for instance between production stages.

3.2.2 The area of the system

The materials handling system works, as mentioned before, in a certain area. Dependence and influence on this is mutual. The area includes among other things the surrounding physical environment, the production process, the external transport system, buying and sales departments, suppliers and storages, the distributors and the customers of the industry etc.

3.3 Definition of planning

A comprehensive flora of definitions of conceptions of the term planning are to be found in the literature. In practice this term is used in different connections and with different meanings. It is often used together with and therefore also confused with expressions like projecting.

The following general description can be made:

1. Planning always refers to a definite process or a definite system. To make continuous planning possible, the system must

first be defined in a description of the system and an objective. In the present work this is a materials handling system.

2. Planning is a future oriented act the aim being to prepare the system for future events. In practice this means for example that one decides a condition of a system with regard to buildings, equipment, labour and organization, which will meet a need during a period of 5-10 years.
3. Planning assumes that one has a choice. Otherwise there is nothing to be planned. In other words, in a planning situation there are always several courses of action.

3.4 Definition of industrialization

The definition of industrialization covers two different but often connected courses. In its simplest and broadest meaning industrialization means that the industrial share of production and employment increases. The second meaning concerns a change within industrial production, a technical revolution of the way to produce. Industrialization therefore means that the introduction of machines or new chemical processes leads to a revolution of the industrial work, where the private worker is subordinated to an integrated machine system within heavy industry. While a technical change, which enables a given product to be produced with less work has to a different extent been carried out within all types of production. The conception technical revolution consequently concerns the technical change whereby the worker instead of being responsible for the instruments is made subordinate to the machines.

Consequently, it is possible to talk about two cases of industrialization with or without technical revolution. From the basis of two sectors of production, agriculture and industry, the two cases of industrialization are discussed here in general.

For example through an increase in agricultural production in

sparsely populated or fertile regions, industrial production can increase in the densely populated or the barren regions. A certain increase in productivity may arise through specialization, but as a result of the decreasing produce within agriculture, the increase will cease when the cultivation limit has been reached (relatively decreasing production for increasing work efforts).

If a technical change occurs within agriculture, the space for industry can, however, also increase totally. Increased produce within agriculture as a consequence of new production methods on the one hand results in fewer persons being needed to be employed within agriculture against an unchanged volume in production. On the other hand the demand for industrial products may increase. The latter assumes that the greater part of the increase in demand which agriculture generates, does not go to provisions.

Through the technical revolution brought about by mechanization or new processes, productivity within industry increases rapidly. In contrast to the effects of the technical change in employment within agriculture, industrial employment will increase as consumption of industrial products expands. Highly increased productivity leads to a fall in the relative price of industrial products, but the increase in quantity enables the industrial share of the production to continue increasing. Modern industrialization connects both aspects - quantitative increase and technical revolution.

A large number of relations can in different ways be regarded as conditions for industrialization. Only conditions applicable to workers, capital and market are mentioned here.

4. THE AIM OF THE MATERIALS HANDLING SYSTEM

In order to secure as good a result as possible when modifying a materials handling system, the objective of the project must be carefully explained. The objectives should be expressed quantitatively or operationally. It results in that they are specific for every project. The character of the objective can, however, be generalized to a certain degree. Examples of such formulations in connection with planning of materials handling systems are:

- Maintain a certain specific service level at the lowest possible cost
- Help to make the total result of the industry as good as possible
- Aid a high speed of sales for the products of the industry
- Help to keep the stock levels for raw materials, products under construction, and finished products reasonable low
- Aid a good work environment and a high safety in the work
- Be easy to adjust to changed conditions and the future development in the industry
- Reduce transportation and materials handling costs
- Improve utilization of room available
- Decrease damages on the goods
- Give a better adjustment of materials handling system to production and distribution
- Improve material control
- Get shorter and more competitive times of delivery and also reduce the number of delays
- Increase productivity.

In connection with the formulation of the aim there are two other important factors to be analysed, namely:

1. Limitations of area

What transports will the system clear off?

2. Timetable

When will the system be ready?

4.1 The integration of the materials handling system and its connection with the main functions in the industry

Traditionally the organization of the industries has been built up with regard to the functions. It has had relatively clear fields of responsibility and rights. The different functions have been studied, organized and controlled as separate activities. (Magee 1967).

This has too often resulted in suboptimizations and perhaps also an insufficient interest in the materials handling system as this has only been a partial activity within one of the functions.

The functions in an industry which can be of special interest in connection with the analysis of the materials handling system are:

- external transports (transportation) or traffic department
- buying department
- design department
- production
- marketing, selling
- development, long-range planning.

In many industries today an integration between internal and external transports is not the matter of course we imagine.

It can have such consequences that the goods must wait for loading and unloading, needless intermediate storings before the goods reach the store or production, higher rates of freight, inferior service of the external transport industries, increased administrative costs, vacant capacity at one industry with simultaneous lacking capacity at another, etc.

4.2 Factors which influence the selection of materials handling system

Components and relations in materials handling system

Components

A materials handling system includes a great number of different components. Often we may only think of the most obvious, and that is transport equipment. To be able to work out a functioning system a great number of other components must be taken into consideration, for instance:

- All the different kinds of goods to be handled or transported
- Packages
- Carriers
- Handling facilities
- Managing personnel
- Supervising personnel
- Routes
- Storage and stockyards, buffer stocks
- Delivery points of the system (type of goods receiving)
- Output from the system
- Facilities for administrative purposes (forms, time tickets, order cards, etc)
- Guiding and control instruments
- Capital resources
- Costs
- Immaterial components like know-how

5. ANALYSING OF EXISTING METHODS

5.1 Methods of planning

Introduction

To be able to realize a planning work it is necessary to have methods of planning. When planning a complex system there are many different factors to be observed. The idea that the whole material flow must be taken into consideration when planning a materials handling system or when there is an intention to make an engagement in the material flow system involves studies of large, complex systems. It should be made clear that in order to realize a real planning so that the stated demands are met, one must work according to methods which make it possible to study the system and consider all the influencing factors. Within the materials handling area, a number of methods of work have been introduced, which can be practised in connection with planning. Some of these start from the scientific methods introduced by Ackoff (1968). These methods are very general and can not be used for planning without comprehensive concretization.

More interesting and useful are the methods that have resulted from practical experiences as these are directly adapted to planning of the materials handling system in a broad sense. Examples of such widely used methods are the Systematic Handling Analysis (SHA), worked out by Richard Muther and Knut Haganäs (1973), and also a method developed by James M Apple (Apple 1963, Apple 1972). Both these methods are basically equal, but Muther respectively Apple have built them up differently, depending on their own background. Muther is a consultant and that is why the SHA is a step-by-step method (Figure 5), including numerous practical instructions and a great strain of means in the form of schedules and diagrams. James Apple was professor of Industrial and Systems Engineering, and he has in view of this fact paid special attention to the systemanalytical aspects in his method. It takes

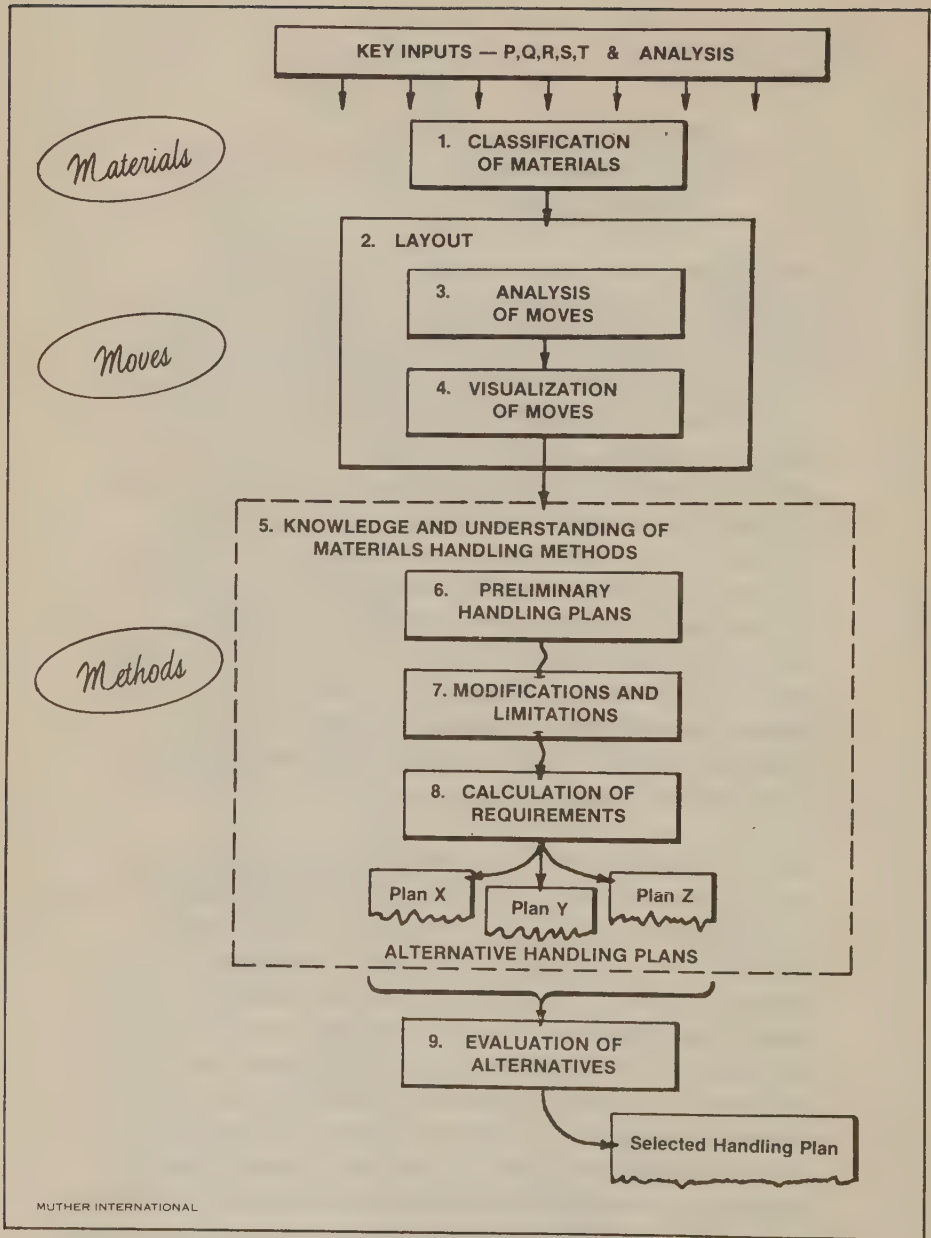


Figure 5. The pattern of procedures for Systematic Handling Analysis. (Muther & Hales 1979).

the form of a planning methodology including phases in different planning levels. Both of the methods have proved useful in research carried out at the Transportation and Materials Handling Engineering Dept of Lund Institute of Technology.

The fundamentals of the methods will be described shortly.

5.2 Muther's method

Richard Muther who worked out the method SHA has tested this method many times in consulting commissions. The method can be said to have its origin from consult work. According to the SHA the planning can be divided into the following phases (Figure 6).

1. External integration
2. Overall handling plan
3. Detail handling plan
4. Installation

Within the limits of the four phases the SHA can be applied to a different extent and with appropriate modifications.

As it apperas from the description, the methodology is general and must be given a concrete form in each specific case. In the book SHA there are suggestions and examples of how a concretization of this kind can be done. The greatest advantage of the SHA-methodology is that it roughly draws up the outline of a methodology which can be concretized when the individual object of planning is known. The methodology is directed towards planning of the materials handling system. It does not deal with the warehouse system.

SHA pattern applies to both phases 2 and 3

The SHA pattern applies to both phase 2 - overall handling plan - and phase 3 - detail handling plans.

1 EXTERNAL INTEGRATION

2 OVERALL HANDLING PLAN

3 DETAILED HANDLING PLANS

4 INSTALLATION

Time →

Phase 1:

Examine all movements to and from the area in question preparatory to integration with the overall handling plan(s).

Phase 2:

Plan the method(s) of moving materials between areas. Make major decisions about system, type of equipment and containers.

Phase 3:

Plan the method(s) of moving materials within each area— between workplaces and/or storage points.

Phase 4:

Prepare drawings and specifications; obtain and install equipment; train workers; follow through.

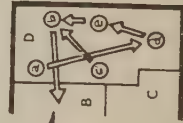
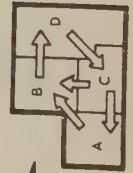
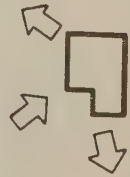


Figure 6. The phases of systematic handling analysis. (Muther & Haganäs 1973).

That is to say, the same pattern of steps prevails, although the degree of application will be more detailed and finite in phase 3.

The handling methods for the detailed areas themselves will have to integrate with the more important overall handling methods selected in phase 2. Additionally, they will have to integrate with other physical facilities; layout, communications equipment, utilities, and the building(s).

The practical importance of the SHA-method

SHA has been used in a more or less modified form by a small number of consulting firms in different parts of the world. The fact these companies have in common provided that they all work within industrial planning and transport planning branch, is that they have by collaboration agreement been connected with the organization Muther International.

It's difficult to speculate about the use of the SHA-method in the future. It will probably be used for proportionately comprehensive projects. Because Muther International among other things arranges courses in "Systematic Handling Analysis" in Western Europe and the USA at regular intervals, the method is spread at least to some of the bigger companies.

The SHA is used advantageously together with a similar method for industrial planning, SLP (Systematic Layout Planning). It is then important to analyse all the time how the basic variables of the SLP, connection, room required and adjustments, and the basic variables of the SHA, material, moves and methods, in principle are all influenced when one or two of them are changed.

The great importance of the SHA is that it makes the only well-known, thoroughly worked, generally practicable and complete system (or decision model) for selection of a materials handling system. Although the method is not used as a whole, studying it gives a very good idea of the problems of the kind of project in

question. Instructions and ideas of how to solve the problems are also given.

5.3 Apple's method

The method of James Apple is described in Material Handling System Design (Apple 1972), which is the result of a comprehensive work. According to Apple the planning can be divided into five phases:

- Defining
- Analysing, investigation
- Synthesizing
- Shaping, design
- Implanting.

Within these phases a lot of different activities must be performed to make a final solution.

J M Apple has made a specification and given priority to the ten most essential practical experiences of material handling analysis work (Larsson & Magnusson 1971). They are:

1. Important to define the purpose clearly
2. Early planning is required
3. Many "white stains" concerning data, costs, suitability etc
4. Courage and self-control are required to overcome big problems
5. Just a little "thinking in broad outline" helps to gain attention and a good acceptance
6. Do not expect too much, too fast
7. A solution must be accepted by those involved so that it will work well
8. Also the best system can be failing
9. Think simply before you think complexly
10. Give careful regard to improving the existing method first - but bear the total system in mind

T M Harrison (1972) gives prominence to a method of analysis opposing the one usually used. For he says that it is an advantage to analyse a factory beginning with the final construction and then go backwards to the raw materials receiving. Only then can the materials handling problem be understood completely. The difference in this approach is in no way trivial.

There can be different ideas about a thing, such as whether to start the materials handling analysis from the existing system - with all its faults - or ignore this completely and develop an ideal system, without any thought of limitations in any form. This is then developed gradually and adjusted to existing conditions. The purpose of the current work has been to avoid the description of extreme points of view as far as possible, and here it is worth pointing out that an unprejudiced but realistic analysis of transport requirements makes the basis of the modification of materials handling system.

The method of work when modifying a materials handling system can be described in different ways and according to different grades of details. An author who has laid much work on this is J M Apple, and his most detailed modified grouping contains 33 facilities divided into 5 stages (Apple 1973). Each grouping fulfils its purpose to reflect the method of work, but it is perhaps somewhat unforeseeable and gives little information regarding important considerations in respective stages or facilities which can be used.

In Plant Layout and Materials Handling (Apple 1963) the following general broad "guide" is mentioned to solve the materials handling problem:

1. Determine and define the problem.
2. Make proper contacts with those involved in the problem and its solution.
3. Set up a method of approach and develop a work schedule.
 - a) Learn the operation
 - b) Develop and accurate layout

- c) Observe operation in detail
 - d) Secure comprehensive factual data
 - e) Investigate methods of communication and control
 - f) Investigate anticipated results
 - g) Weigh and analyse all data
 - h) Develop improvements
 - i) Select equipment
 - j) Determine required structural changes
 - k) Plan necessary controls
 - l) Provide adequate communications
 - m) Develop operating procedures
 - n) Determine personnel requirements
 - o) Determine and compare costs, savings, and advantages
 - p) Consider intangible advantages
 - q) Summarize capital requirements and rate of return.
4. Prepare report or presentation.
 5. Obtain approvals (revise as necessary).
 6. Supervise installation.
 7. Follow up after installation.

5.4 The Lund method

A simple but very useful method for planning a transport system which can be used when it is a question of internal as well as external transports, has since 1965 been applied to the education at the Transportation and Materials Handling Engineering Department, Lund Institute of Technology, with great success (Bjerner 1982). The exercises use concrete examples to select a transport system for different kinds of industries. The model aims at an economical optimum. The following working stages give the working procedure in general:

1. Make a systematical analysis of the need of transports.
Obtain and compile information on quantity of goods, quality of goods, possibility of unit loads, need of labour etc.
 Make a transport diagram (flow chart) and flow process chart.

2. Analyse conceivable materials handling methods and types of materials handling equipment for the different internal and external requirements of transport. Mention the characteristics and data of the equipment and transport alternatives.
 3. Make at least two proposals for the transport system. Make a main proposal for the transport system with the help of the analysis. Motivate the selection of the system, e.g. by stating different alternative advantages and disadvantages, and also make a cost calculation. Make a systematical going through of the possibilities to eliminate or simplify the transports. Try to eliminate narrow sections (so called bottle necks). Avoid suboptimization (optimization without regard to the industry as a whole). The proposal should be worked out in a clear and simple way, with e.g. the the help of a flow process chart and a schematic drawing.
 4. Evaluate the proposals in a systematic way.
- 5.5 Research and development within the field in some other countries

It is relatively easy to follow research and development concerning methods for analysing, planning and selection of the materials handling systems at universities and other research institutes in Sweden via direct contacts, reports from research councils, articles etc. Information and results concerning current research and development abroad are considerably more difficult to obtain. Here are just a few remarks.

In order to obtain information of value for the current research project, obtain viewpoints, ideas and take part in the experiences and also receive mutual benefit from research results, the author has read many articles and had thorough discussions on the project with the prominent pioneer and researcher, Richard Muther, who several times has been a visiting professor at the Transportation and Materials Handling Engineering Department, Lund Institute of

Technology. This contact has shown that American research and development in particular has valuable a contribution to give.

In the USA there are several researchers in this field. Muther and Apple (past) are the most prominent of them. Part of their work has been dealt with in this study. Their points of view regarding the work in question have been of great importance when modifying the guiding principles and working methods to select a materials handling system which is introduced by the study.

The important research in "materials handling" in West-Germany, is mainly directed towards the technical modification of materials handling equipment. The same thing may be said of the research in East-Germany.

In France the research in this field at university level seems to be of importance. The development is carried out with the help of branch organizations, consulting firms and within private industries.

In England the strength of the materials handling is its engineering, the weakness its modification of system. This is left to the user who often lacks capacity for and knowledge of being able to evaluate, select and incorporate different components in their transport systems.

6. DEMAND ANALYSIS

6.1 Area of Problems

Many of the technologies exploited today in the most advanced industrialized countries are in general not directly applicable to the developing countries with completely other needs and structures. Differences e.g. in relative factor prices, size of market and model of consumption, create other needs and requirements for technology. Exploitation of industrial technology in a mainly agrarian society can lead to heavy distortions in e.g. exploitation of factors and resource allocation.

In spite of this, several studies indicate that only a very limited adaptation of technology for developing countries is carried out (Skinner 1968, Wells 1973). This is thought among other things to be connected with the fact that the choice and implementing of technology is normally made on industrial level - contrary to national level. Multinational companies normally choose to introduce a method already developed and known. By doing so, high development expenses (including saving of time) are avoided and one gets a method that one knows functions in other connections.

From a business economical point of view it is then reasonable to choose a method already existing and utilized, partly because the marginal expenses will be very low in relation to the average expenses (and lower than the marginal expense in order to develop an adapted technology), and partly because you know the value of the existing method better than the value of a method not yet developed (uncertainty concerning technology that you do not have the use of yet). However, the deficient adaptation of the method can depend e.g. on quality and technical standard.

6.2 Quality

To achieve high quality the Greek companies make high demands upon machine equipment as well as raw material and components. Most of the raw material and components as well as machines of "non-precision character" are, however, bought locally. The more technological knowledge is introduced, the more advanced components can be manufactured locally (that is, the need for internal deliveries increases). And the more extensively local subsuppliers can meet with the demands in quality and other conditions, the more can be bought locally.

6.3 Standardization

Besides uniform and high quality in products, the importance of standardization is crucial. In other words, uniform and high quality requires standardization of equipment, components and final products. Through standardization you try to make a large number of parts identical. A great number of components and semi-finished products are bought either locally or from abroad and these must be completely interchangeable irrespective of their origin. This requires standardization of machines, equipment, working routines etc.

6.4 Raw material

Quality requirements and standardization impose certain minimum requirements as to quality, type, size etc. on raw material and components that are an integral part of the products

Deliveries can come from Greek or foreign sources, supplied either by companies or individual suppliers.

Access to a great number of Greek and foreign suppliers facilitates the maintenance of a high technical standard.

In order to secure raw material of high quality, the Greek

companies have integrated backwards through a number of industrial contacts. Even though the quality aspects are the most important in this connection, variations in market prices can lead to changes in purchase sources.

6.5 Technical Knowledge

Improvements in quality, technical standard and technical solutions have been the dominating, impelling forces throughout the companies' development. This has imposed a comprehensive technical knowledge concerning raw materials, special machines and special tools.

6.6 Labour force in Greece

For a long time Greece has been one of the countries with the lowest salaries in Europe. The access to an uneducated labour force is good. Labour force with experience and vocational training is still a comparatively scanty production factor.

It can be difficult to get productional managers with competence.

One of the difficulties in starting is to recruit personnel with sufficient competence from other divisions of the concern.

Here are some opinions about the character of the Greek labour force:

- are loyal to the company
- are easy to instruct
- want to do a good job
- do not have industrial experience
- do not have any sense of responsibility and ambition
- show deficiency in the ability to collaborate.

An important ability of Greek productional managers is that they can absorb directions, instructions, standards, etc. in order to get a functioning production system according to the rules of the company. It is often difficult to introduce information to Greek personnel, especially during the starting period. In order to succeed you must, quite simply "be able to sell your idea so that the receiver grasps it as his own idea".

6.7 Working Environment Legislation

Another field where the production systems are controlled by public control means is that of the working environment. This control is mostly obtained through legislation, e.g. limited noise values, concentration of various air substances, safety regulations or requirements for lighting conditions.

In Greece, legislation covering that part of the working environment that touches upon production systems is still under-developed compared to industrialized countries.

6.8 Industrialization in Greece. Statistical data

Greece today can be considered as a country on the way towards industrialization. Industrialization is primarily made through large foreign companies and the Greek public enterprises. On the other hand, there is no general industrial milieu and experience to support the growth of private Greek companies. Foreign dominance is remarkable within technological development.

Industrial research and development is primarily carried out within the scope of the foreign companies' activity. Technical know-how within the industry comes to a very limited extent from Greek sources. The low level of specialized technical education in the country has also influenced several categories of personnel, mainly foremen and managers. Furthermore, the social and cultural model

has contributed to the lack of interest in the industrialization process.

At this point some statistical data is shown, obtained from the Statistical Yearbook of Greece (Athens 1981).

Είδος μηχανημάτων	1978	1979				Agricultural machinery
	Σύνολον Χώρας Greece, total	Σύνολον Χώρας Greece, total	Πεδινά κοινότητες Level communes	Ήμιορεινά κοινότητες Semi-moun- tainous communes	Όρεινά κοινότητες Mountain- ous communes	
Γεωργικοί έλκυστήρες (σύνολον) Εξ αυτών κάτω των 18 HP....	195.404 73.136	210.206 77.538	134.218 40.430	47.255 20.359	28.733 16.749	Agricultural tractors, total Thereof under 18 HP
Θεριζοαλωνιστικά μηχανάκια	5.744	6.058	4.456	1.168	434	Harvesters - threshers
Απλά θεριστικά μηχανάκια	5.044	5.297	3.824	894	579	Harvesters
Αλωνιστικά μηχανάκια παντός τύπου	824	830	516	204	110	Threshers, all types
Απλά χορτοσυλλεκτικά μηχανάκια	7.144	7.770	5.753	1.308	709	Hay rakes
Εκκοκοκιστικά μηχανάκια άραβοσίτου	2.144	2.094	1.288	501	305	Leaf - removers for maize
Κορυφολόγοι γαλακτός	2.319	2.311	1.098	502	711	Cream separators
Αντλίες πετρελαιοκίνητοι	91.026	92.021	67.182	17.967	6.872	Pumps, diesel oil
» βενζινοκίνητοι	84.497	84.202	49.203	21.578	13.421	» petrol
» ηλεκτροκίνητοι	67.770	71.338	49.346	17.038	4.954	» electric
» λοιπά (άτμοκίνητοι, άνε- μοκίνητοι, ζωοκίνητοι κλπ.)	13.410	14.836	3.508	9.229	2.099	» other (steam or wind operated, animal-drawn etc.)
Συγκροτήματα τεχνητής βροχής ..	101.500	107.880	86.614	16.207	5.059	Sprinkling units
Εκκολαπτικά μηχανάκια	532	513	356	112	45	Incubators
Σπартικά μηχανάκια σίτου	26.463	28.248	21.971	4.666	1.611	Sowing machines, for wheat
Σπартικά μηχανάκια βάμβακος, άρα- βοσίτου κλπ.	22.427	21.530	19.136	1.996	398	Sowing machines, for cotton, maize etc.
Σιτοδιαλογείς (τριέρις)	2.562	2.458	1.580	538	340	Corn-graders
Μηχανοκίνητοι: { α) ψεκαστήρες ..	99.819	101.490	60.254	26.206	15.030	Power: { a) sprayers
{ β) θειωτήρες ..	13.817	14.545	8.389	3.975	2.181	{ b) dusters

Figure 7. Agricultural machinery: 1978 and 1979.

Χώρα	Είδη διατροφής — Food					Σύνολον προϊόντων — All commodities					Country
	1976	1977	1978	1979	1980	1976	1977	1978	1979	1980	
Ελλάς	128	124	132	125	135	128	122	132	124	133	Greece
Αίγυπτος	102	118	112	114	117	106	102	107	110	115	Egypt
Αυστρία	108	107	109	109	116	108	107	109	109	116	Austria
Βέλγιον ⁽¹⁾	101	106	106	107	110	101	106	106	107	110	Belgium ⁽¹⁾
Γαλλία	107	108	114	122	126	107	108	114	122	126	France
Γερμαν. Όμ. Δημοκρατία	100	106	112	111	113	100	106	112	112	113	Germany F.R.
Γιουγκοσλαβία	123	127	124	127	126	123	127	121	127	126	Yugoslavia
Δανία	98	109	109	114	116	98	110	109	114	116	Denmark
Ελβετία	114	114	116	123	123	114	114	116	123	123	Switzerland
Ηνωμένοι Πολιτείες ...	118	122	121	127	122	117	122	120	126	121	United States
Ηνωμένος Βασιλειον ...	102	114	116	119	122	102	114	116	119	122	United Kingdom
Ιαπωνία	101	109	108	108	99	101	107	107	107	98	Japan
Ισπανία	129	128	141	138	145	128	128	140	138	144	Spain
Ισραήλ	131	135	132	133	127	133	138	138	138	133	Israel
Ιταλία	105	107	111	116	119	105	107	111	116	119	Italy
Καναδάς	120	122	125	113	121	117	120	123	111	120	Canada
Κύπρος	90	99	97	100	99	90	99	97	100	99	Cyprus
Νορβηγία	106	115	123	116	118	105	115	123	116	118	Norway
Όλλανδία	120	124	132	139	141	121	125	132	139	142	Netherlands
Σουηδία	114	115	118	114	121	114	115	118	114	121	Sweden
Τουρκία	129	129	134	140	143	130	130	134	139	141	Turkey
Φινλανδία	119	105	108	108	111	119	105	108	108	111	Finland

Πηγή: Στατιστική Έπετηρίς των Ήνωμένων Έθνών, 1979/80.

Σημειώσεις: Ο δείκτης ειδών διατροφής περιλαμβάνει γεωργικά προϊόντα και προϊόντα ζωικής προελεύσεως, προοριζόμενα διά τας ανάγκες των ανθρώπων. Ο συνολικός δείκτης περιλαμβάνει, επιπροσθέτως, ίνας, καπνόν, βιομηχανικά ελαϊώδη σπέρματα, καουτσούκ, τσίον και καφέ.

Οι δείκτες καταρτίσθησαν υπό του FAO διά τής χρησιμοποίησεως των κατά περιοχάς συντελεστών σταθμίσεως, οι οποίοι καταρτίσθησαν βάσει των τιμών τής περιόδου 1961-1965 και των δεδομένων τής γεωργικής παραγωγής εκάστης χώρας. Έχουν άφαιρεθή αι ζωοτροφαι και οι σπόροι, οι οποίοι έχρησιμοποιήθησαν κατά την παραγωγικήν διαδικασίαν.

(1) Περιλαμβάνονται και τα στοιχεία του Λουξεμβούργου.

Source: United Nations Statistical Yearbook, 1979/80.

Note: The food index relates to the production of crops and livestock products for human consumption. The all commodities index includes, in addition, fibres, tobacco, industrial oilseeds, rubber, tea and coffee.

These index series were constructed by FAO by applying regional weights based on 1961-1965 price relationships to the country production figures. Deductions were made for feed and seed used in the production process.

(1) Including data for Luxembourg.

Figure 8. Index numbers of agricultural production of selected countries. 1969-71 = 100.

Χώρα και κλάδος	1974	1976	1977	1978	1979 (1) 1978	Country and branch
Ελλάς						Greece
Γενικός	96	111	113	121	102	General
Ορυχεία (15)	103	108	112	109	103	Mining (15)
Βιομηχανία (16)	96	111	112	121	102	Manufacturing (16)
Ηλεκτρισμός - Φωταίριον	94	112	119	133	103	Electricity - gas
Αίγυπτος						Egypt
Γενικός	85	117	127	...	...	General
Ορυχεία	151	151	183	...	...	Mining
Βιομηχανία	86	114	121	...	...	Manufacturing
Ηλεκτρισμός	87	118	137	...	...	Electricity
Αυστρία						Austria
Γενικός	107	106	110	112	105	General
Ορυχεία (8)	104	123	114	121	91	Mining (8)
Βιομηχανία (9)	108	107	110	112	105	Manufacturing (9)
Ηλεκτρισμός	95	100	107	109	107	Electricity
Βέλγιον						Belgium
Γενικός	111	109	109	111	108	General
Ορυχεία (6)	107	97	91	83	95	Mining (6)
Βιομηχανία	111	109	109	114	108	Manufacturing
Ηλεκτρισμός	105	116	115	124	107	Electricity
Βουλγαρία						Bulgaria
Γενικός	91	107	114	122	111	General
Ορυχεία (10)	95	101	99	103	111	Mining (10)
Βιομηχανία (11)	91	107	114	122	111	Manufacturing (11)
Ηλεκτρισμός - Ατμός	91	109	118	126	111	Electricity - Steam
Γαλλία						France
Γενικός	108	109	111	112	106	General
Ορυχεία	105	98	95	94	108	Mining
Βιομηχανία (13)	109	111	111	113	105	Manufacturing (13)
Ηλεκτρισμός - Φωταίριον	99	109	113	122	112	Electricity - Gas
Γερμανική Δημοκρατία						Germany F. R.
Γενικός	106	109	111	113	101	General
Ορυχεία (14)	105	98	94	95	112	Mining (14)
Βιομηχανία (14)	107	109	112	113	105	Manufacturing (14)
Ηλεκτρισμός - Φωταίριον	98	111	112	120	112	Electricity - Gas
Γιουγκοσλαβία						Yugoslavia
Γενικός	95	104	114	123	107	General
Ορυχεία	95	103	107	110	96	Mining
Βιομηχανία	94	103	113	124	108	Manufacturing
Ηλεκτρισμός - Φωταίριον	99	109	121	128	108	Electricity
Δανία						Denmark
Βιομηχανία (12)	106	111	113	115	101	Manufacturing (12)
Ηλεκτρισμός	100	112	120	112	121	Electricity
Ελβετία						Switzerland
Γενικός	114	101	107	107	—	General
Βιομηχανία	117	102	106	107	—	Manufacturing
Ηλεκτρισμός - Φωταίριον	89	85	107	99	97	Electricity - Gas
ΕΣΣΔ						USSR
Γενικός (21)	93	105	111	116	104	General (21)
Ορυχεία (22)	95	104	109	111	99	Mining (22)
Βιομηχανία (23)	93	105	111	116	104	Manufacturing (23)
Ηλεκτρισμός - Ατμός	94	109	111	117	113	Electricity - Steam
Ηνωμένων Βασιλείων						United Kingdom
Γενικός (19)	105	102	106	110	105	General (19)
Ορυχεία	90	126	188	232	121	Mining
Βιομηχανία	107	101	103	104	104	Manufacturing
Ηλεκτρισμός - Φωταίριον - Υδωρ	99	103	107	110	121	Electricity - Gas - Water
Ηνωμένες Πολιτείες						United States
Γενικός	110	111	117	124	106	General
Ορυχεία	102	101	105	110	101	Mining
Βιομηχανία	111	112	119	126	107	Manufacturing
Ηλεκτρισμός - Φωταίριον	98	104	107	111	110	Electricity - Gas
Ιαπωνία						Japan
Γενικός	112	111	116	122	108	General
Ορυχεία	106	100	103	106	95	Mining
Βιομηχανία (6)	114	111	116	123	108	Manufacturing (6)
Ηλεκτρισμός - Φωταίριον	97	108	114	120	105	Electricity - Gas
Ισπανία						Spain
Γενικός	107	106	119	—	—	General
Ορυχεία	97	102	113	—	—	Mining
Βιομηχανία	108	106	120	—	—	Manufacturing
Ηλεκτρισμός - Φωταίριον	98	110	114	—	—	Electricity - Gas
Ισραήλ						Israel
Γενικός	98	104	111	117	108	General
Ορυχεία (4)	90	79	80	88	94	Mining (4)
Βιομηχανία (5)	98	105	112	119	108	Manufacturing (5)

Figure 9. Index numbers of industrial production of selected countries. 1975 = 100.

Χώρα και κλάδος	1974	1976	1977	1978	1979 ⁽¹⁾ 1978	Country and Branch
Ιταλία						Italy
Γενική	110	112	114	116	110	General
Μining	138	104	99	100	106	Mining
Βιομηχανία (15)	111	113	114	116	111	Manufacturing (15)
Ηλεκτρισμός - Φυσικών - Υδρ.	99	112	114	119	107	Electricity - Gas
Καναδάς						Canada
Γενική	106	106	109	113	106	General
Μining (2)	110	103	106	98	103	Mining (2)
Βιομηχανία	107	106	109	117	106	Manufacturing
Ηλεκτρισμός - Φυσικών - Υδρ.	100	109	116	122	107	Electricity - Gas - Water
Κύπρος						Cyprus
Γενική	120	123	140	111	111	General
Μining (1)	176	110	121	141	107	Mining (1)
Βιομηχανία (3)	116	129	148	111	111	Manufacturing (3)
Ηλεκτρισμός	115	112	121	131	109	Electricity
Νορβηγία						Norway
Γενική	94	106	108	110	104	General
Μining	34	144	164	268	103	Mining
Βιομηχανία	103	102	102	100	103	Manufacturing
Ηλεκτρισμός - Φυσικών - Υδρ.	99	105	93	105	115	Electricity - Gas
Ολλανδία						Netherlands
Γενική	105	106	107	108	103	General
Μining	96	107	107	98	103	Mining
Βιομηχανία	107	105	106	108	99	Manufacturing
Ηλεκτρισμός - Φυσικών - Υδρ.	97	108	108	115	121	Electricity - Gas - Water
Σουηδία						Sweden
Γενική	102	99	96	95	115	General
Μining (18)	117	99	87	78	148	Mining (18)
Βιομηχανία	102	100	97	95	118	Manufacturing
Τουρκία (7)						Turkey (7)
Γενική	92	109	111	111	111	General
Μining (32)	93	103	111	111	111	Mining (32)
Βιομηχανία (15)	92	109	111	111	111	Manufacturing (15)
Ηλεκτρισμός - Φυσικών - Υδρ.	90	118	111	111	111	Electricity - Gas - Water
Φινλανδία						Finland
Γενική	104	103	104	107	112	General
Μining	101	116	124	120	110	Mining
Βιομηχανία	104	102	102	104	111	Manufacturing
Ηλεκτρισμός - Φυσικών - Υδρ.	99	105	114	123	116	Electricity - Gas - Water

Πηγή: Στατιστική Έπιτροπή των Ηνωμένων Εθνών, 1979/80.

Source: United Nations Statistical Yearbook, 1979/80.

- (1) Έκδοσης αναφοράς του δείκτη του Ιαν.-Ιουνίου 1979 προς την έκδοση του 1978.
- (2) Περιλαμβάνονται και οι γεωτρήσεις, οι οποίες κατά ISIC περιλαμβάνονται εις τον κλάδο 10.
- (3) Δεν περιλαμβάνονται τα προϊόντα άνθρακος, πετρελίου και βασικών μεταλλικών ορυκτών.
- (4) Μόνο εξόρυξη μη μεταλλικών ορυκτών.
- (5) Δείκτης υπολογισθείς από τον Γραφείο Στατιστικής των Ηνωμένων Εθνών.
- (6) Δεν περιλαμβάνονται οι εκδόσεις και οι εκδόσεις. (Διά την Τεχνολογικών, μόνοι οι εκδόσεις).
- (7) Δείκτης ακριβούς του εγχώριου προϊόντος (εις σταθερά τιμές του 1968).
- (8) Περιλαμβάνονται τα προϊόντα λατομείων.
- (9) Περιλαμβάνονται τα λατομεία λίθου, άγλυου και χυμού, δεν περιλαμβάνονται τα προϊόντα, οι εκδόσεις, οι εκδόσεις και τα προϊόντα άνθρακος.
- (10) Περιλαμβάνονται οι εκδόσεις και οι εκδόσεις.
- (11) Περιλαμβάνονται τα προϊόντα, δεν περιλαμβάνονται οι εκδόσεις.
- (12) Δεν περιλαμβάνονται οι γεωτρήσεις και οι γεωτρήσεις ορυκτών.
- (13) Δεν περιλαμβάνονται τα είδη, οι εκδόσεις.
- (14) Τα λατομεία λίθου, άγλυου και χυμού περιλαμβάνονται εις την μεταλλουργία.
- (15) Περιλαμβάνονται οι εκδόσεις του μεταλλικού.
- (16) Περιλαμβάνονται οι εκδόσεις ορυκτών.
- (17) Δεν περιλαμβάνονται οι εκδόσεις των μεταλλικών.
- (18) Δεν περιλαμβάνονται τα λατομεία άγλυου και χυμού.
- (19) Περιλαμβάνονται οι εκδόσεις.
- (20) Δεν περιλαμβάνονται τα μεταλλικά.
- (21) Περιλαμβάνονται οι εκδόσεις, παραγωγή, μηχανοκίνητων ταχυδρόμων, ορυκτών και άγλυου.
- (22) Δεν περιλαμβάνονται οι εκδόσεις των άγλυου πετρελίου και γεωτρήσεων, εις και οι προπαρασκευαστικές εργασίες δια την άνευση ορυκτών.
- (23) Περιλαμβάνονται οι εκδόσεις, οι εκδόσεις, δεν περιλαμβάνονται οι εκδόσεις.

- (1) Percentage ratio of the index for January-June 1979 to that for January-June 1978.
- (2) Including contract drilling which is classified to construction in the ISIC.
- (3) Excluding coal and petroleum products and basic metals.
- (4) Extraction of non-metallic minerals only.
- (5) Index computed by the United Nations Statistical Office.
- (6) Excluding printing and publishing. (Czechoslovakia, publishing only).
- (7) Index numbers of gross domestic product (at constant prices of 1968).
- (8) Including magnesite products.
- (9) Including stone quarrying, clay and sand pits. Excluding sawmills, printing and publishing, and coal products.
- (10) Including logging and fishing.
- (11) Including manufactured gas. Excluding publishing.
- (12) Excluding ship-building and repairing.
- (13) Excluding clothing.
- (14) Stone quarrying, clay and sand pits are included in manufacturing.
- (15) Including magnesite roasting.
- (16) Including car repairs.
- (17) Excluding some groups of miscellaneous manufacturing.
- (18) Excluding clay and sand pits.
- (19) Including construction.
- (20) Excluding metal mining.
- (21) Including logging, motion picture production, cleansing and drying.
- (22) Excluding oil and natural gas drilling, prospecting and preparing sites for the extraction of minerals.
- (23) Including commercial fishing. Excluding publishing.

Figure 10. Continued. 1975 = 100.

Ιούνιος June	Ιούλιος July	Αύγουστος August	Σεπτέμ. Septem.	Οκτώβρ. October	Νοέμβρ. Novem.	Δεκέμβρ. Decem.	Branches
199,7	187,8	172,5	215,0	195,7	196,6	200,7	Industry
125,5	125,5	206,4	264,1	178,3	184,5	168,8	Food manufacturing industries
271,4	306,8	324,4	254,2	204,1	187,5	210,1	Beverage industries
217,4	257,4	229,1	206,1	160,3	117,6	120,4	Tobacco manufactures
231,5	182,2	148,5	219,9	224,9	237,5	244,5	Manufacture of textiles
253,5	215,9	167,8	247,7	234,1	220,9	256,7	Clothing and footwear
215,1	206,1	181,9	199,8	179,4	184,2	175,4	Wood and cork
95,6	95,1	62,0	88,1	103,7	108,6	112,3	Furniture
204,2	184,1	160,4	199,5	186,9	184,8	184,7	Manufacture of paper and paper products
116,1	105,8	101,8	124,9	104,5	123,5	125,6	Printing and publishing
83,5	69,3	74,4	92,2	90,1	87,0	81,2	Leather
204,0	177,9	110,3	195,2	191,6	191,1	192,6	Manufacture of rubber and plastic products
195,1	199,1	149,6	218,8	220,6	220,7	213,2	Chemical industries
270,1	283,1	277,6	291,2	259,1	304,6	271,1	Manufacture of products of petroleum and coal
241,7	245,0	234,9	241,4	218,1	219,7	213,3	Manufacture of non-metallic mineral products
191,9	192,6	175,5	200,8	186,7	176,2	185,5	Basic metal industries
208,5	192,5	153,9	183,0	195,1	179,4	211,6	Manufacture of metal products, except machinery and transport equipment
116,6	108,5	99,4	127,1	112,3	113,8	125,3	Manufacture of machinery etc. except for electrical and transport equipment
264,2	202,5	127,9	244,0	236,4	232,4	240,4	Manufacture of electrical machinery, apparatus, appliances and supplies
164,2	145,8	146,2	176,5	168,0	175,6	197,6	Manufacture of transport equipment
152,4	215,1	75,7	226,9	189,7	222,1	232,0	Miscellaneous manufacturing industries
- Production indices of food-beverages-tobacco and of the remaining branches							
169,5	183,2	233,2	250,4	180,2	173,7	168,6	Food-beverages-tobacco
206,6	188,9	158,5	206,8	199,3	201,9	208,1	Remaining branches
- Production indices of capital goods, durable consumption and consumption goods							
195,4	183,6	168,7	195,9	187,2	182,4	193,1	Capital goods
237,8	207,5	135,7	219,5	217,4	219,6	230,6	Durable consumption goods
196,1	186,7	179,1	225,2	197,3	201,2	200,7	Consumption goods

Note: The general index of mining, manufacturing and electricity-gas production is given in table XI: 8.

(1) The annual indices were derived from the by-branch indices before they were adjusted for the unequal number of working days in each month.

Figure 11. Monthly indices of industrial production for the year 1980. Base: Monthly average production 1970 = 100,0.

Γεωγραφικόν διαμέρισμα και νομός Geographic region and department	Αριθμός κιλοβάτ (1) Number of kilowatts		Γεωγραφικόν διαμέρισμα και νομός Geographic region and department	Αριθμός κιλοβάτ (1) Number of kilowatts	
	1979	1980		1979	1980
Σύνολον Ἑλλάδος—Greece, total ..	4.862.195	5.410.220	Θρᾷσκία—Thessaly	130.470	130.470
Θερμικὴ ἰσχύς—Thermal	3.416.195	3.994.220	Καρδίτσης—Karditsa	130.000	130.000
Ἵδρoηλεκτρικὴ ἰσχύς—Hydro-electric ..	1.416.000	1.416.000	Λαρίσης—Larisa	—	—
Περιφέρεια Πρωτεύουσας—Greater Athens	470.000	470.000	Μαγνησίας—Magnisia	470	470
Λοιπὴ Στερεὰ Ἑλλάς καὶ Εὐβοία—Rest of Central Greece and Euboea	1.590.700	1.523.790	Τρικάλων—Trikala	—	—
Αἰτωλία καὶ Ἀκαρνανία—Aetolia and Akarnania	757.000	757.000	Μακεδονία—Macedonia	1.709.500	2.009.500
Ἀττικὴς (ὑπόλοιπον)—Attica (rest) ..	451.900	684.370	Γρεβενῶν—Grevena	—	—
Βοιωτίας—Boeotia	—	—	Δράμας—Drama	—	—
Εὐβοίας—Euboea	381.800	382.450	Ἰμαθίας—Imathia	1.800	1.800
Εὐρυτανίας—Evyritania	—	—	Θεσσαλονίκης—Salonica	—	—
Φθιώτιδος—Phthiotis	—	—	Καβάλας—Kavala	—	—
Φωκίδος—Phocis	—	—	Καστορίας—Kastoria	—	—
Πελοπόννησος—Peloponnesos	621.600	621.600	Κιλίκης—Kilkis	—	—
Ἀργολίδος—Argolis	—	—	Κοζάνης—Kozani	1.638.000	1.938.000
Ἀρκαδίας—Arkadia	620.000	620.000	Πέλλης—Pella	69.000	69.000
Ἀχαΐας—Akhaia	1.600	1.600	Πιερίας—Pieria	—	—
Ἠλείας—Ilia (Elis)	—	—	Σερρών—Serres	700	700
Κορινθίας—Korinthia	—	—	Φλωρίνης—Florina	—	—
Λακωνίας—Lakonia	—	—	Χαλκιδικῆς—Khalkidiki	—	—
Μεσσηνίας—Messenia	—	—	Θράκη—Thrace	900	800
Ἰόνιοι Νῆσοι—Ionian Islands	19.455	19.355	Ἔβρου—Evros	900	800
Ζακύνθου—Zante	8.550	8.450	Ξάνθης—Xanthi	—	—
Κερκύρας—Corfu	1.505	1.505	Ροδόπης—Rodopi	—	—
Κεφαλληνίας—Cephalonia	9.400	9.400	Νῆσοι Αἰγαίου—Aegean Islands	186.220	188.855
Λευκάδος—Lefkas	—	—	Δωδεκανήσου—Dodecanesos	90.675	89.335
Ἠπειρός—Epirus	10.300	10.300	Κυκλάδων—Cyclades	42.450	44.840
Ἄρτης—Arta	—	—	Λέσβου—Lesvos	27.880	30.680
Θεσπρωτίας—Thesprotia	—	—	Σάμου—Samos	9.420	11.080
Ίωνίνων—Yanina	—	—	Χίου—Chios	15.795	12.920
Πρεβέζης—Preveza	10.300	10.300	Κρήτη—Crete	123.050	135.550
			Ἡρακλείου—Iraklion	93.750	93.750
			Λασιθίου—Lasithi	—	—
			Ρεθύμνης—Rethymni	—	—
			Χανίων—Canea	29.300	41.800

(1) Τα δεδομένα ἀντιπροσωπεύουν τὴν κατὰ τὸ τέλος τοῦ ἔτους ἰσχύοντων τῶν γεννητριῶν, τῶν παραγωγῶν ἡλεκτρικῆς ἐνέργειας θερμικῆς καὶ ὑδροηλεκτρικῆς προελεύσεως, πρὸς δημοσίαν χρῆσιν. Δὲν περιλαμβάνονται ἡ ἰσχύς τῶν βιομηχανικῶν ἐργοστασίων, τῶν παραγόντων πρωτογενῆ ἐνέργειας δι' ἰδίαν χρῆσιν.

(1) The data represent the nominal end-of-year capacity of all generators in plants producing thermo-electricity and hydro-electricity for public use. Capacity of industrial plants generating electricity primarily for their own use is not included.

Figure 12. Electric energy: Installed capacity by geographic region and department: 1979 and 1980.

Χώρα	1975	1976	1977	1978	1979	1980	Country
Ελλάς	4.664	4.728	4.759	4.800	4.831	4.835	Greece
Αίγυπτος	3.955	3.944	3.918	4.000	4.000	4.500	Egypt
Αυστρία	10.026	10.537	11.620	12.313	12.407	12.673	Austria
Βέλγιον	9.809	10.109	10.129	10.225	10.400	11.116	Belgium
Βουλγαρία	7.060	7.210	7.082	7.518	7.990	8.240	Bulgaria
Γαλλία	46.289	48.406	52.451	54.571	56.434	62.904	France
Γερμανική Ομοσπονδία Δημ.	70.112	77.051	79.131	80.764	82.519	82.108	Germany F.R.
Γιουγκοσλαβία	9.043	10.073	10.601	12.081	13.450	14.030	Yugoslavia
Δανία	5.958	6.286	6.453	6.459	6.768	7.651	Denmark
Ελβετία	11.816	12.016	12.200	12.540	13.560	13.700	Switzerland
ΕΣΣΔ	217.484	228.307	237.670	245.441	255.991	262.400	USSR
Ηνωμένοι Πολιτείες	527.346	550.369	576.206	599.058	615.686	630.782	United States
Ηνωμένων Βασιλείων	69.376	67.386	66.781	66.503	68.055	69.363	United Kingdom
Ιαπωνία	112.285	116.871	122.349	131.218	137.939	144.780	Japan
Ισπανία	25.756	26.591	27.444	28.278	28.278	30.470	Spain
Ισραήλ	2.251	2.230	2.460	2.688	2.728	2.728	Israel
Ιταλία	39.103	40.659	42.583	43.497	44.698	46.552	Italy
Καναδάς	61.352	65.993	70.575	74.484	77.227	79.700	Canada
Κύπρος	239	269	269	269	269	269	Cyprus
Νορβηγία	16.926	17.158	17.559	18.040	18.710	18.955	Norway
Ολλανδία	15.454	15.538	17.223	18.338	19.083	19.723	Netherlands
Σουηδία	23.135	24.445	25.108	26.091	27.000	27.000	Sweden
Τουρκία	4.187	4.364	4.727	4.869	5.119	5.119	Turkey
Φινλανδία	7.395	8.012	9.065	9.305	9.092	9.250	Finland

Πηγή: Στατιστική Έπετηρίς των Ήνωμένων Εθνών, 1979/80.

Σημειώσεις: Τα δεδομένα αντιπροσωπεύουν την κατά το τέλος του έτους ισχύον όλων των γεννητριών, οι οποίες δύνανται να λειτουργήσουν ταυτόχρονα.

Source: United Nations Statistical Yearbook, 1979/80.

Note: The data represent the nominal end-of-year capacity of all generators available for simultaneous operation.

Figure 13. Electric energy: Installed capacity in selected countries. Thousand kw.

Χώρα	1975	1976	1977	1978	1979	1980	Country
Ελλάς	16.142	17.861	18.996	21.050	22.102	22.510	Greece
Αίγυπτος	10.386	12.256	14.054	15.150	16.750	18.520	Egypt
Αυστρία	35.205	35.331	37.684	38.069	40.644	41.966	Austria
Βέλγιο	41.066	47.349	47.099	50.838	52.249	53.646	Belgium
Βουλγαρία	25.237	27.747	29.710	31.377	32.368	34.835	Bulgaria
Γαλλία	185.312	203.094	210.845	226.692	241.124	257.752	France
Γερμανική Ομοσπονδία Δημ.	301.802	333.651	335.320	353.429	372.182	368.772	Germany F.R.
Γιουγκοσλαβία	40.040	43.573	48.580	51.250	54.966	58.935	Yugoslavia
Δανία	18.687	20.928	22.436	20.789	22.204	25.438	Denmark
Ελβετία	42.994	36.241	45.903	42.350	45.551	48.231	Switzerland
ΕΣΣΔ	1.038.607	1.111.420	1.150.075	1.201.896	1.238.196	1.295.000	USSR
Ηνωμένες Πολιτείες	2.003.002	2.123.406	2.211.031	2.285.880	2.318.783	2.356.139	United States
Ηνωμένο Βασίλειο	271.987	276.879	283.092	287.689	299.960	281.549	United Kingdom
Ιαπωνία	475.794	511.793	532.609	563.990	589.644	612.010	Japan
Ισπανία	82.385	90.821	93.803	99.534	105.779	110.194	Spain
Ισραήλ	9.712	10.361	11.108	11.874	12.436	12.528	Israel
Ιταλία	147.333	163.550	166.545	175.041	180.522	186.305	Italy
Καναδάς	273.392	294.043	317.196	335.708	353.054	366.677	Canada
Κύπρος	716	796	860	919	977	1.034	Cyprus
Νορβηγία	77.485	82.133	72.432	80.997	89.010	83.989	Norway
Ολλανδία	54.259	58.138	58.285	61.597	64.473	64.793	Netherlands
Σουηδία	80.573	86.416	90.018	92.901	95.063	96.250	Sweden
Τουρκία	15.569	18.231	20.565	21.726	22.522	23.275	Turkey
Φινλανδία	25.134	27.885	31.563	33.871	37.151	38.577	Finland

Πηγή: Στατιστική Έπετηρίς των 'Ηνωμένων Έθνών, 1979/80.

Σημειώσεις: Έκτός άλλης υποδείξεως, τα στοιχεία αναφέρονται εις την παραγωγήν των ηλεκτρογεννητικών κέντρων και, ως εκ τούτου, περιλαμβάνουν την κατανάλωσιν και τας απώλειας των σταθμών παραγωγής.

Source: United Nations Statistical Yearbook, 1979/80.

Note: Unless otherwise stated, the data relate to production of generating centres, and therefore, include station use and transmission losses.

Figure 14. Electric energy: Production of selected countries. Million kwh.

6.9 Requirements of a suitable method to cover the needs of the Greek industries

In Greece there doesn't exist any technique for analysing, planning and selection of materials handling systems, and there is no education in this field. The analysis, the planning and the selection of materials handling systems and the solution of materials handling problems are not given any special study (practical way). Nor are the functions of the industries considered as a whole. Usually, a single type of equipment is used to solve materials handling problems, but a single type and variety of equipment has specific uses and advantages and often two or more are combined into the solution of a single problem.

The engineers in the industries continue to accept the existing materials handling systems, because they haven't the appropriate knowledge to modify or to improve them. Industries and consulting firms in Greece feel the need for a complete method for analysing, planning and selection of materials handling systems which would actively cover the industrial need and not only be of a theoretical character.

- They want to have a method which can be used as a guide with direct practical application, and not a method which must be considered or modified so that it will suit the application.
- It should not be of a general character but a specific one totally covering the requirements of the Greek industries.
- It must refer to what working steps should exist in a systematic way of application and state in what order the working steps must come.
- It must be suitable to use without comprehensive concretization.
- It must give all the necessary material that is required in applying the various working steps and no unnecessary material so that the materials handling engineer is not involved aimlessly. (Phases in different planning levels within a lot of different activities must be performed to make a final solution.)

- It must simplify various situations and not cause problems.
- It must help the materials handling engineer during the time that he is occupied with the project even if he has not been involved from the beginning. It must help his work at all stages.
- It must have flexibility in the completing, abording and permission of the almost existing stages.
- It must be easy to use including easy facilities.
- It must be possible to be applicated independently, whether it is a question of a new system or an alteration of an old one.
- Because of the increasing rhythm of productivity, the method must be applicable to both big and small, simple and complicated materials handling systems.
- The application of the method must be wide covering every type of Greek industry and workshop.
- Because the new established industries in Greece recommend consulting firms abroad, on purpose not only to improve the operating way but to get the necessary equipment so that the operation will be possible, the method must be able to solve materials handling problems of the future, because of the peculiarity in the operation of the industries (e.g. no standardization in the production, order changes from the customer during the time of the process, etc.).
- It must contain the necessary theoretical and practical material, to be used both in consultancy work and technical teaching.
- The method with an unprejudiced but realistic analysis of transportation requirements will make the basis of the modification of a materials handling system, not ignoring existing conditions and social development. A far too quick increase in the mechanization level for materials handling systems can have negative effects according to the hitherto existing experiences.

- It must be suited to the mentality of the workers in Greece today (no robots, no driverless trucks, no advanced computers).
- It must be independent of various co-operations, agreements and organizations, helping in this way the industrialization of Greece only.
- It must include a project planning (formulation of the problem - purpose and limits - Time and resource plan).
- It must refer to how and where you can get information, and to the factors that influence the product, quantity, transport routes, transport equipment, time factors.
- It must give recommendations of ways of finding additional "equivalent space" without involving new construction.
- It must give the marks of a good layout.
- It must give the types of layout problems.
- It must give the factors to be considered in the classification of materials and their analysis.
- It must refer to the factors for the choice of the type of the machine-arrangement.
- It must refer to the factors which are involved in the analysis of moves, as well as the facilities to do it.
- It must refer to the various ways of increasing one's knowledge and understanding of the materials handling methods.
- It must suggest another type of equipment other than trucks, conveyors, hoists and cranes.
- It must refer to suggestions of various ways to save energy in regard to common transportation equipment (trucks, conveyors, hoists and cranes).
- It must indicate the modification and limitation that are involved in every materials handling plan.
- It must give all possible ways of calculating the requirements.

7. TESTING THE EXISTING METHODS ACCORDING TO ANALYSIS OF REQUIREMENTS

- A. The methods which start with the scientific methods introduced by Ackoff (1968) are very general and cannot be used for planning without comprehensive concretization.
- B. Muther's methodology is general and must be given a concrete form in each specific case. It is not suitable to be used without comprehensive concretization. The method includes extensive practical instructions and a great strain of means in the form of schedules and diagrams which are difficult to use. There are also two phases (phase I and phase IV) which are frequently not a part of the materials handling engineer's specific problem.

Muther's methodology can be used in consultancy work but it is unsuitable for elementary technical teaching because of difficult facilities. It is not quite applicable to both large and small, simple and complicated materials handling systems. Because Muther International arranges among other things courses in SHA, in Western Europe and the USA, at regular intervals, the method should be spread to a certain extent, at least to some of the bigger companies.

Muther's method ignores of course the existing conditions and the social development in Greece.

Muther's method doesn't include a project planning (formulation of the problem - purpose and limits - Time and resource plan). It doesn't give recommendations of ways of finding additional "equivalent space" without turning to new constructions. It doesn't give the marks of a good layout. It doesn't give the types of layout problems.

It doesn't refer to various ways to save energy in regard to common transportation equipment (trucks, conveyors, hoists and cranes). It doesn't give all the possible ways to calculate the requirements (e.g. simulation).

- C. J M Apple stressed in particular analytical aspects in his method. It has the form of a planning methodology, including phases in different planning levels. Within these phases a lot of different activities must be performed to make up a final solution. It includes the necessary theoretical and practical material for teaching in every degree of technical education but not in consultancy work. In his work on the method when modifying a materials handling system, he gives little information about important considerations at respective stages or facilities which can be used. His method doesn't refer to suggestions for various ways to save energy in regard to common transportation equipment (trucks, conveyors, hoists and cranes). It hasn't the flexibility in the completing, abording or permission of the almost existing stages. It doesn't use easy facilities. It is not suited to the mentality of the workers in Greece today.
- D. T M Harrison's method can't be used as a guide for direct practical application. It doesn't refer to what working steps should exist in a systematic way of application and in what order the working steps must come. It is not suitable to be used without comprehensive concretization. It doesn't give all the necessary material that is required in applying the various working steps. It can be applied to consultancy work but not to teaching in every degree of technical education.
- E. The method applied to the case studies at the Transportation and Materials Handling Engineering Department of Lund Institute of Technology aims at an economical optimum.

8. PRESENTATION AND ANALYSIS OF ANALYTICAL AND DEVELOPMENT WORK COVERING THE NEED OF THE GREEK INDUSTRIES

The method presents working steps for analysing, planning and selection of materials handling systems, as well as factors which must be taken into consideration when analysing, planning and selecting materials handling systems for Greek industries.

The method is divided into seventeen working steps (figure 15). In the first steps 1) Project planning 2) Collection of information and 3) Pre-analysis, you will obtain the data and the information needed to carry out step 10) Demand analysis. In working step 15) you will obtain a number of alternative materials handling systems which will be evaluated in the step 16). The final selection of an alternative will be made in the step 17).

During the working procedure it is possible to limit the project and deepen the analysis so it becomes more detailed. The work means that you often must go back to the working steps carried out earlier, formulate the aim and delimitations once again, change the time plan and complete the information collected and the pre-analysis. This must never be interpreted as a failure but is a natural way to work when searching an "optimal" materials handling system.

8.1 Working step 1: project planning

Working step 1 consists of

- formulation of problem
- aim and delimitation
- time and resource plan.

Examples of facilities for project planning are shown in Figure 16.

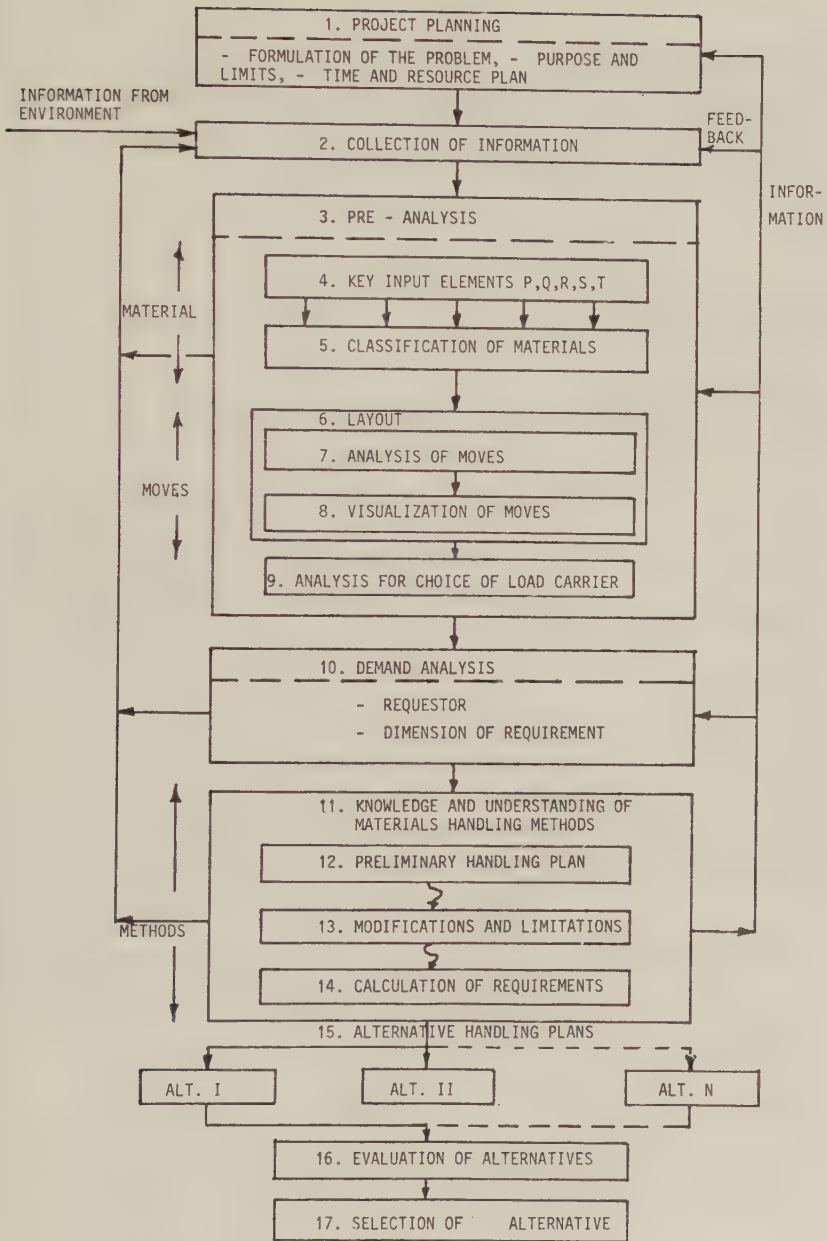


Figure 15. The model of procedures.

It is necessary that the project planning is described briefly and clearly, because you normally in the course of the project repeatedly will go back to the project planning and change it.

A formulation of a problem means that

- you are forced to get into the real problem
- you have a clear idea of the problem during the project work
- it will be easier to inform others of the problem.

A formulation of a problem must contain a concrete description of the problem.

The aim shall

- indicate requirements to be met
- simplify information of the project
- facilitate the valuation of the materials handling system and transportation equipment.

The formulation of the problem is used as a basis in order to formulate the aim.

To be able to apply the systematic materials handling analysis to a concrete problem, a planning of time and resource consumption is required:

- Estimation of how long time (e.g. working hours) is needed for the different working steps
- Calculation of necessary calendar time with regard to given personnel resources and other tasks of the personnel
- Cost estimate.

8.2 Working step 2: collection of information

The collection of information must give the basis required to perform the other working steps. The collection of information

is often carried through the course of the whole project time with the main point in the beginning, as well as with recurrent completings. The information includes the requirements which appear from the demand analysis. The following demand analysis figures may be useful (Figures 17 and 18).

<u>REQUIREMENT</u>	<u>DEMANDER</u>
HORIZONTAL MOVE	MATERIAL/LOAD CARRIER
VERTICAL MOVE	MATERIAL FLOW
GRADIENT	WORKING STATIONS
CARRYING CAPACITY	TRANSPORT ROADS
FUNCTIONS	BUILDINGS
SPACE REQUIRED	ADMINISTRATION
ERGONOMY	PERSONNEL
FUNCTIONAL RELIABILITY	MANAGEMENT
RESISTANCE	SERVICE ESTABLISHMENT
DEAD WEIGHT/AXIAL PRESSURE	SUPPLIERS
LIFE	CUSTOMERS

Figure 17. Demand analysis: transportation equipment.

<u>REQUIREMENT</u>	<u>DEMANDER</u>
TRANSPORT CAPACITY	MATERIAL/LOAD CARRIER
NEED OF ENERGY	MATERIAL FLOW
NEED OF SERVICE	WORKING STATIONS
NEED OF PERSONNEL	TRANSPORT ROADS
AMOUNT OF INVESTMENT	BUILDINGS
COST OF CAPITAL	ADMINISTRATION
COST OF RUNNING	PERSONNEL
REPLACEMENT SYSTEM	MANAGEMENT
FLEXIBILITY	SERVICE ESTABLISHMENT
SAFETY (SAFETY DEVICE)	SUPPLIERS
NEED OF EDUCATION	CUSTOMERS

Figure 18. Demand analysis: transportation system.

Besides the demand analysis figures the following check lists can be useful.

Product

Physical quantities (size, form, weight, damage risk, condition)

Load unit (size, form, weight, damage risk).

Quantity-flow (or movement)

Quantity of goods-intensity (e.g. ton/year, m³/day, pieces/hour)

Peak loads

The appearance of the flow (continuous, discontinuous).

Transport roads (or the terminal points of the transport)Internal transports

Transport distance

Physical qualities of the transport road: ground, level, the carrying capacity of road, floor and roof

Availability to electric power, compressed air

Delimitations of space.

Transportation equipment

Technical data: capacity, dimension, speed, availability, maintenance, reliability of service, special technical data

Economic data: cost, price

Quantity

Need of man power

Service.

Time factors

Transportation time

Handling time

Storage time

Operation time

Working time

etc.

Costs

Cost price

Maintenance and running charges

Level of interest

Economical life

Installation costs

Rent costs

Terms of payment

Wage costs.

8.2.1 Where and how you can get the information

8.2.1.1 Product

Interviews with personnel in question. Interviews with each person connected with the problem and asking questions about his desire for improvements.

Measurements

Books.

Books are possible to obtain from the National Library of Greece.

The address is:

National Library of Greece

Eleftheriou Venizelou 32

T.T. 143 - Athens

8.2.1.2 Quantity-flow

Existing quantity-flow

Interviews with personnel in question

Internal statistics of the company

Company accounts

Measurement (work samplings, time studies)

etc.

Future quantity-flow

Forecasts

Long-range planning of the company

Labour market

Public and communal investigations.

Reports may be obtained from the Library of the Greek Association of Graduate Engineers, T.E.E., in Athens and from the National Statistical Service of Greece, Ε Σ Υ Ε.

The addresses of the above-mentioned authorities are:

T.E.E.	Ε Σ Υ Ε
Karagiorgi Servias 4	Likourgou 14-16
Sintagma	T.T. 112
Athens-Greece	Athens-Greece

(Competition between similar industries is always very hard. Consequently, visits to the Greek industries are considered very difficult. However, students' visits are made to certain departments but detailed analyses concerning their activities are not possible.)

Statistical year-book and monthly book issued by the National Statistic Service of Greece.

Technical development

Many contacts with specialists from abroad are made and they are purposely continued with the help of the managers and the industrial personnel, not only to improve the operating way but to get the necessary equipment, so that the operation will be possible. At the same time many suggestions from various industries abroad about new equipment are taken into consideration.

Enquiries

It is possible to obtain information concerning Greek industries from the federation of Greek industries (it is called S.E.V. in Greece) and from the Ministry of National Economy, Industry Section, as well as from the Greek Association of Graduate Engineers in Athens (T.E.E.), see above.

Federation of Greek Industries	Ministry of National Economy
Ksenofontos 5	Industry Section
Athens T.T. 118	Michalakopoulou 80
Greece	Athens-Greece

8.2.1.3 Routing

Transport roads

Interviews with personnel in question

Own measurements.

8.2.1.4 Supporting services

Transportation equipment

Information given by manufacturer and general agent

Own statistics and own experiences

User of the intended equipment

Books and professional journals

Representation.

The information from the manufacturer should, if possible, be controlled. However, the data may be given in different forms, and that is why it is often difficult to make direct comparisons.

Deterioration may cause a fall in capacity, why extra capacity is often required.

8.2.1.5 Timing factors

Time factors

Measurements made by the company (work department)

Own measurements

Working hours acts

Agreements etc.

8.2.1.6 Costs

Information given by manufacturer and general agent

Own information and statistics

User of the equipment in question

Tests as a basis for cost estimate

Agreements etc.

Examine critically the information from the informer.

The terms of payment can generally be valued through calculation of the price of today to make them comparable if they are not equal. Whether to rent or buy the equipment is naturally an important question.

8.3 Working step 3: pre-analysis

In the pre-analysis you carry out an analysis of "suppliers" and "customers" to the system to be projected. Supplier here means the activity function which delivers the material into the system while the customer is the activity function which receives the material outside the limit of the system.

The limit of the system within which the materials handling system shall be analysed and projected or rationalized

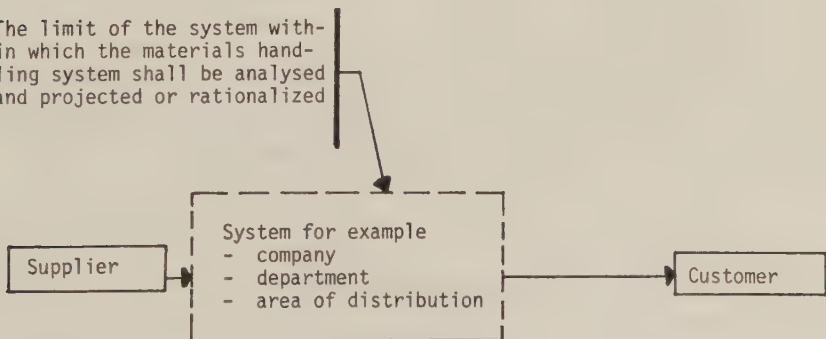


Figure 19. Definition of "supplier" and "customer".

From the definition it appears that suppliers and customers are not always suppliers and customers of a company, but can be dispatching respectively receiving departments, functions or activities within a company.

The pre-analysis should also include an analysis of the functions and activities which shall be included or are included in the system.

8.4 Working step 4: input elements P,Q,R,S,T

The key input elements or preliminary information, needed to analyse a materials handling problem are:

- P Products or Materials (parts, items, commodities)
- Q Quantities (sales-or-contract volume)
- R Routing (operating sequence and process requirements)
- S Supporting services (such as inventory control, order processing, maintenance)
- T Time (timing and operating times).

Further explanation of these elements is indicated in figure 20.

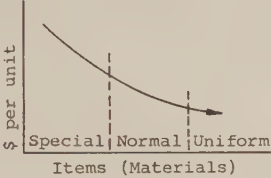
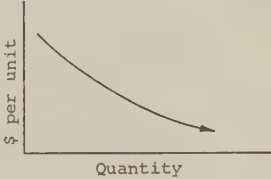
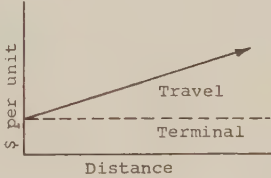
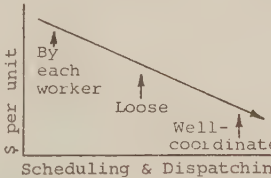
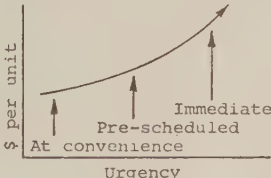
8.4.1 Product

Physical quantities (size, form, weight, damage risk, condition)
Load unit (size, form, weight, damage risk)
etc.

8.4.2 Quantity-flow (or movement)

For each move there is both an intensity of flow and certain conditions affecting or influencing the flow (or movement).

- a) The intensity of flow (quantity of materials per period moving on a route).

P PRODUCT (Material, Parts, Items)	The transportability of products and materials depends on the <u>characteristics</u> of the item and of the <u>container</u> used.* Furthermore, in each given plant, some types of items are more <u>accustomed</u> to being handled than others.	
Q QUANTITY (Volume, Usage)	Quantity has two different meanings: Quantity per <u>Unit of Time</u> (Intensity of Flow) Quantity per <u>Trip</u> (Payload) Either way, the larger the quantity moved, the lower the cost per unit moved.*	
R ROUTING (Origin to Destination)	Each move involves a fixed <u>terminal</u> cost and a varying <u>travel</u> cost.* Be aware of the physical condition of the route and of the <u>cost steps</u> which occur when the conditions change (indoor or outdoor movements) or the direction changes.	
S SUPPORTING SERVICES (Surroundings)	Dispatching procedures,* maintenance personnel, order-filling paperwork, and the like, are <u>services</u> on which the handling system and equipment will depend; plant layout, building features, and storage facilities are <u>surroundings</u> within which they must operate.	
T TIME (Timing, Regularity, Urgency, Duration)	One important time or timing factor is the <u>regularity</u> with which the movement has to be performed. Another is the <u>duration</u>--how long will the work continue to be necessary? Urgency* and synchronization also affect handling costs.	

*See example at right.

Figure 20. Five Key elements influence materials handling costs.
(Muther & Haganäs 1973).

Intensity is the term used to describe the amount of material moving (or to be moved) in a certain period of time over a specific route.

Intensity of flow (Figure 21) is the quantity of material moved per period of time.

b) The conditions of the flow (or movement)

Conditions of the flow include:

1. Quantity conditions
2. Service conditions
3. Timing conditions.

The condition of flow cannot be measured in a definite unit.

But using a letter code we are able to define the condition for each move.

Example: Condition "a" - steady flow with small variations.

8.4.3 Routing

TRANSPORT ROADS (or the terminal points of the move)

Internal transports

- a) Transport distance. (The distances are long because of the bad layout. Aimless moves are taken place.)
- b) Physical qualities of the transport road. (Ground level. There are some types of production, e.g. in steel works, where the floor must be specially structured of earth. Because of this use of all types of transportation equipment is considered impossible.)
The carrying capacity of road, floor and roof.
- c) Availability to electric power. (Interruption of current occurs sometimes. In the provinces there may be limited availability to electric power. The local electric power

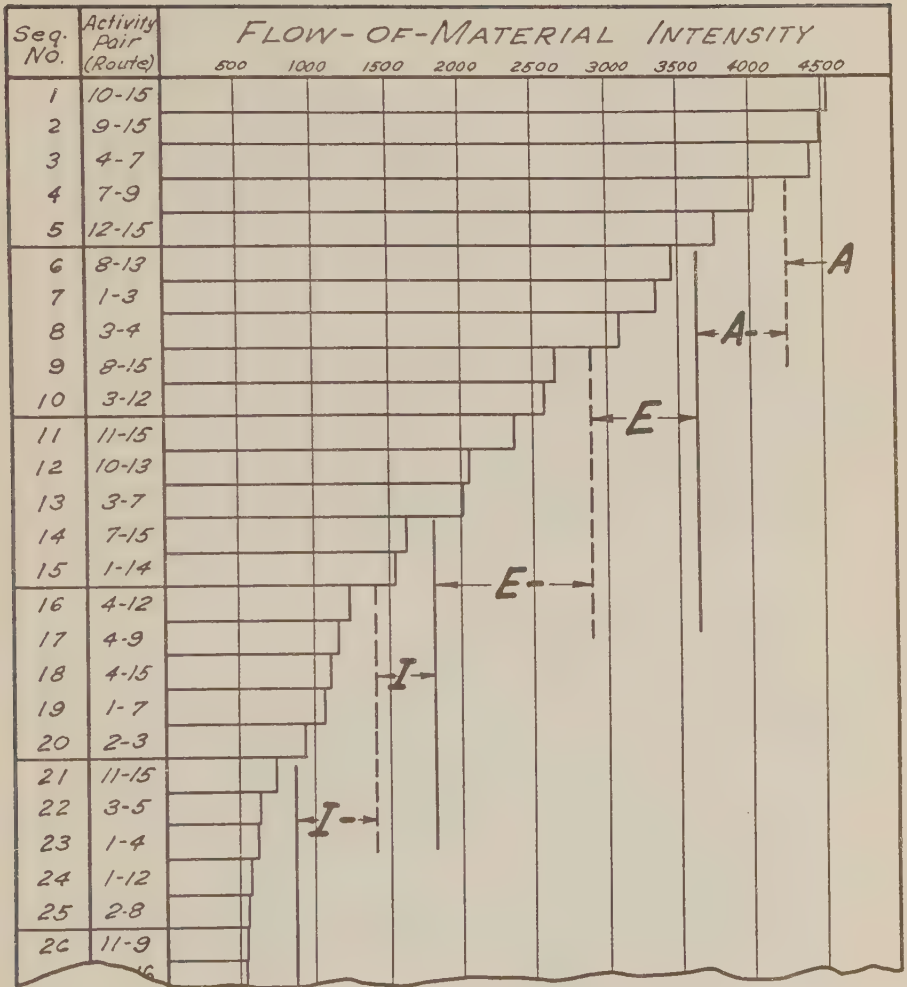


Figure 21. Calibrating or converting flow-of-material intensities against the vowel-letter rating scale. (A=absolutely necessary, E= especially important, I=important, O= ordinary, U=Unimportant, X=not desirable, XX=extremely undesirable). (Muther 1973).

station hasn't the possibility to provide unlimited amount of electric energy.)

- d) Compressed air.
- e) Delimitation of place. (The delimitation of place is a very important factor to be considered. The delimitation of place is a very big problem for the Greek industries. It is difficult to lease buildings in the Athens district.)

RECOMMENDATIONS

Ways of finding additional "equivalent space" without going to new constructions are listed below.

1. Increase working hours - third shift, weekends, overtime
2. Improve methods, processes, equipment
3. Re-design products or simplify product line or components
4. Readjust inventory policy, possibly with revised plan of distribution
5. Overhaul production planning and control to get more from existing facilities
6. Initiate a housekeeping campaign and scrap drive to capture wasted space
7. Rearrange the existing layout for better space utilizations - even though something else may have to be sacrificed
8. Go up or overlead - with mechanical handling, stacking, service-storage balcony
9. Lease nearby space and move storage, offices, or customer service areas there, thus freeing space to expand operations at the existing plant (the use of public warehouses falls into this category)
10. Buy, rather than make, items that are marginal; subcontract certain products or components
11. Sell the existing building, rather than expand, and buy or lease another
12. Decentralize. Divide the operations into two or three groups and spread to leased or available buildings in other communities
13. Buy not or merge with another company and integrate the work of both.

8.4.4 Supporting services

Transportation equipment

- a) Technical data: capacity
dimension
speed
availability
reliability of service
special technical data.
- b) Economical data: cost price
The cost price plays a decisive role in the selection of the transportation equipment. The industries are not willing to invest money in expensive transportation equipment. In certain cases it is possible to invest money in expensive transportation equipment under the presupposition that the concrete transportation equipment will reduce the materials handling costs to a large extent.
- c) Quantity
- d) Need of manpower. As the usual types of transportation equipment (lift trucks, conveyors, hoists, and cranes) exist on the Greek market, schools educating truck drivers do not have the possibility of training truck drivers for all types of transportation equipment.
- e) Service. Service for all types of transportation equipment is difficult. Some of the industries have the possibility to repair accidental damage to common transportation equipment, and repairs are carried out with the help of the workshop personnel.

8.4.5 Timing

Time factors

Handling time

Transportation time

Both are long due to manual work in the main and insufficient transportation equipment.

Storage time

Most Greek industries do not have room for storage of raw material. When this is delivered from the suppliers it is placed near the first production process and exposed in the environment. It has a negative effect on the quality (e.g. oxidation).

The trucks come to the terminal for the unloading of raw material without back fork elevators. The raw material is loaded on the trucks without pallets. The operation is completely manual. It has a negative influence on the storage time of the raw material.

Generally, storage time is long due to lack of technique. A bad storage can cause enormous costs and loss of time.

The operation time may be long due to poor equipment and damages.

Working time

etc.

8.4.6 Costs

Cost price

Maintenance and running charges

Level of interest

Economical life

Installation costs

Rent costs

Terms of payment. Installment is the most common term of payment.

Wage costs.

8.4.7 Visualizing the many aspects of a handling problem

Techniques

Once an approach has been selected, the engineer may use a variety of techniques. While most if not all tools of the profession may be applicable to a given situation, some are especially helpful in material handling projects. Such techniques are those which

specifically address themselves to the analysis of:

- Materials - The physical and nonphysical (scheduling, timing, etc) characteristics of the items.
- Moves - The origin, destination and path of those items.
- Methods - The means by which the materials are moved, either existing or planned.
- Costs - The quantification of methods in terms that readily relate to other aspects of organizational objectives.

Most material handling texts identify materials, moves and methods as fundamental to analysis, and include a wealth of techniques to analyse these fundamentals. Materials handling analysis, therefore, involves analysing the materials to be moved, analysing the moves that must be made, and establishing practical economic methods to accomplish the movement of the materials.

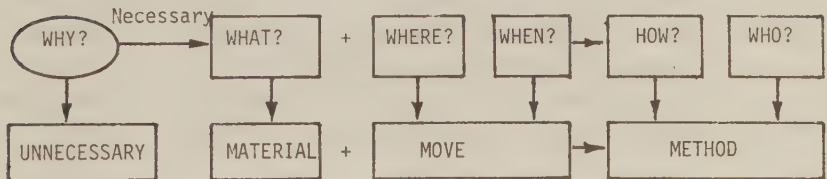


Figure 22. The relation between material, move and method.

8.5 Working step 5: classification of materials

Basically, we want each class of materials to be capable of being handled in the same way - that is to say, by the same handling method. There are two reasons for grouping all the different items into a small number of materials classes: first classification simplifies our analysis; and second, it helps us split or break down the problem into solvable parts.

Recommendations

Figure 23 shows the material classes and the factors that must be considered in classification of materials.

Quantity is also particularly significant. Many materials have a high volume (fast movers), other have a small quantity (frequently "special order"). Large quantities of any item will generally be moved differently than small quantities. In addition, the mix of products or materials is important from the standpoint of both handling methods and technique of analysis.

Timing factors must be recognized, as indicated in part 8.4.5. Urgent moves cost more and call for different handling methods from those that can be made with no rush. Interruptions in the flow will cause problems other than when the flow is steady. Seasonal changes, too, can influence the class of material.

Similarly special control problems often determine the classification. Narcotics, ammunition, valuable furs, alcoholic liquor, jewelry, and food products are a few of the items that are typically controlled by a government regulation, municipal restrictions, corporate policy, or company-wide standard practice.

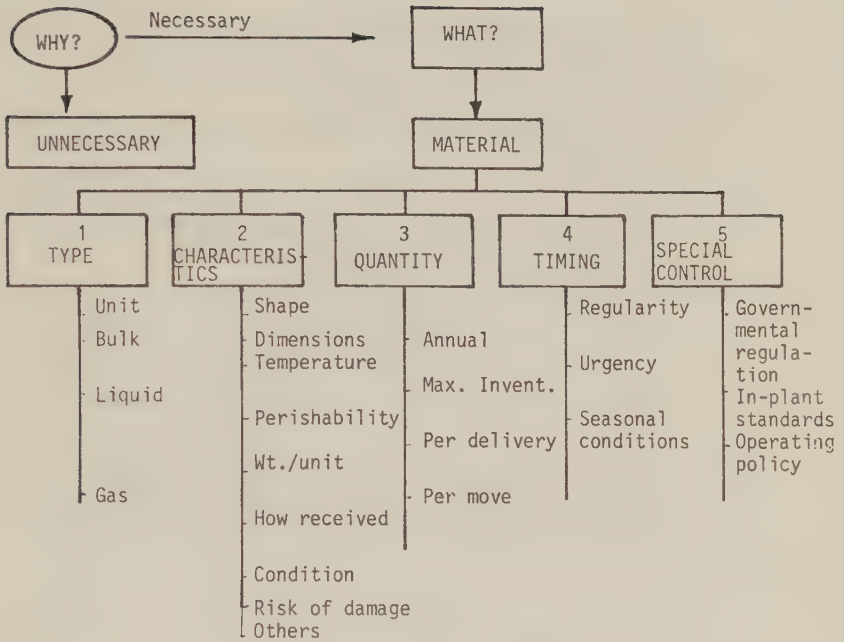


Figure 23. The material classes.

8.6 Working step 6: layout

8.6.1 Definition

Plant layout can be defined as the process of arranging departments within a factory. Of course, it also includes work stations in a department and equipment in a work station.

Basically, you are arranging areas. And to do that, you must find the answers to two questions:

1. What areas to be arranged, and
2. What are the interactions or relationships between those areas?

8.6.2 What we need to know about the layout

For materials handling analysis there are basically four things we want to know which we can get from the layout plan:

1. Where the origins and destinations of each move are located physically.
2. What routes and known methods of handling materials over those routes are already established or generally decided upon in the prior phase of planning.
3. What kind of space is involved in each activity-area from which, through which, and to which material is to be moved (floor loads, ceiling heights, column spacing, overhead-support strength, outdoors or inside, heated or not, dust-free, and the like).
4. What is going on and/or what arrangement or rough layout exists (or is generally planned) within each activity-area from which and to which material is to be moved.

8.6.3 Types of layout

There are three so-called classical types of layout:

1. Layout by Fixed Position
2. Layout by Process
3. Layout by Product.

In each of these three different layout situations, the handling exerts a definite influence:

Layout by fixed position	Product (or material) is relatively large. Quantity is relatively small. Process is relatively simple. Handling is usually characterized as Large or very Sturdy (heavy capacity) for major and components, as Mobile or Flexible for assembly parts, and relatively Occasional.
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Layout by Process (by function)	Product (or material) is relatively diversified. Quantity is moderate or small. Process is dominant or expensive. Handling is usually characterized as Mobile or Flexible, and (if fixed) as Versatile, Adaptable and Intermittent.
Layout by Product (line production)	Product (or material) is relatively standardized. Quantity is relatively high. Process is relatively simple. Handling is usually characterized as Fixed, Straight or Direct, and relatively continuous.

8.6.4 Arrangement of machines

You cannot say that the one or the other arrangement of machines is the best one without knowing the conditions of production. It is not usual that you find the above mentioned types of arrangement in the purest form in industry, but it is often a question of combinations of the different types.

The choice of a type of arrangement will be made with regard to:

- Products
- Quantities
- Methods of production
- Service, facilities and media support
- Working environment
- Time.

Besides this you should pay attention to delimitations such as building construction and demands for safety.

8.6.5 Types of layout problems

Layout problems are of several types:

Design change - Frequently a change in the design of a part calls for changes in the process or operation to be performed. This change may require only minor alterations of the existing layout, or it may result in an extensive re-layout program, depending on the nature of the change.

Enlarged department - If, for one reason or another, it becomes necessary to increase the production of a certain part or product, a change in the layout may be called for. This type of problem may involve only the addition of a few machines for which room can easily be made, or it may call for an entirely new layout if the increased production calls for a process different from the one used before. For example, if compressors were being made in hundreds, ordinary toolroom equipment might be used. However, if the schedule were changed to thousands it might be expedient to install a related group of special-purpose machines.

Reduced department - This problem is nearly the reverse of what was stated above. If production quotas were reduced drastically and permanently, it would be necessary to consider using a process different from the one previously used for high production. Such a change would probably require the removal of present equipment and planning for the installation of other types of equipment.

Adding a new product - If a new product is added to a line, and it is similar to the products already being made, the problem is primarily one of enlarging a department. If, however, the new product differs considerably from those in production, a different problem presents itself. The present equipment may be used by adding a few new machines here and there in the existing layout, with a minimum of rearrangement; or it may be found necessary to set up a completely new department or section - possibly a new plant.

Moving a department - Moving a department may, or may not, present a major layout problem. If the present layout is satisfactory, it is necessary only to shift to another location. If, however,

the present layout has not been satisfactory, an opportunity presents itself for the correction of past mistakes. This may amount to a complete re-layout of the area in question.

Adding a new department - This problem may arise from a desire to consolidate, let us say, the drill press work from all departments into one central department; or it may result from the need for establishing a department to do work never before performed. Such a case would arise if it were decided to make a part which had previously been purchased from an outside firm.

Replacing obsolete equipment - This may require movement of adjacent equipment to provide additional space.

Change in production methods - Anything more than a small change in a simple workplace is very likely to have an effect on adjacent workplaces or areas. This will require a reworking of the area involved.

Cost reduction - This, of course, could be the cause or result of any of the above situations.

Planning a new facility - This presents the biggest problem in layout. Here the engineer generally is not limited by restrictions of existing facilities. He is free to plan the most effective layout he can devise. Buildings can then be designed to house the layout after it has been completed. This is where the ideal in layout can be attained. The facility can be completely laid out for the most efficient manufacturing. Then walls can be planned around the layout and the proper form of physical structure decided upon.

8.6.6 Layout and materials handling

When developing the materials handling plans for an existing layout, the distances are already established. More likely than not, however, we can change the layout if we can justify sufficient

savings. Therefore, one is frequently involved in the analysis of both materials handling and layout. Of course, when the project involves a new layout as a part of planning the improved handling methods, then the planner must integrate the two. Besides he will have the possibility of suggesting layout changes (in Working step 13), after he has made his analysis of moves and when modifying the preliminary handling methods. In any case, when the handling methods are finally selected, they should be chosen on the basis of their operating in conjunction with a specific layout plan. Just as the materials handling analysis rests on the three fundamentals of Materials, Moves, and Methods, the layout planning has three fundamentals. These are Relationships, Space, and Adjustment (Figure 24). Another fact that ties layout and handling together is that both are developed from the same Input Elements: P,Q,R,S,T. Figure 25 shows the pattern of procedures for systematic layout planning, SLP.

8.6.7 Layout testing

The marks of a good layout

In view of the preceding discussion, it would appear that an efficient layout has certain desirable characteristics which should be evident from even a casual survey or observation. Among the most important of these are:

1. Planned activity interrelationships
2. Planned material flow pattern
3. Straight-line flow
4. Minimum back-tracking
5. Auxiliary flow lines
6. Straight aisles
7. Minimum handling between operations
8. Planned materials handling methods
9. Minimum handling distances
10. Processing combined with material handling
11. Movement progresses from receiving towards shipping
12. First operations near receiving

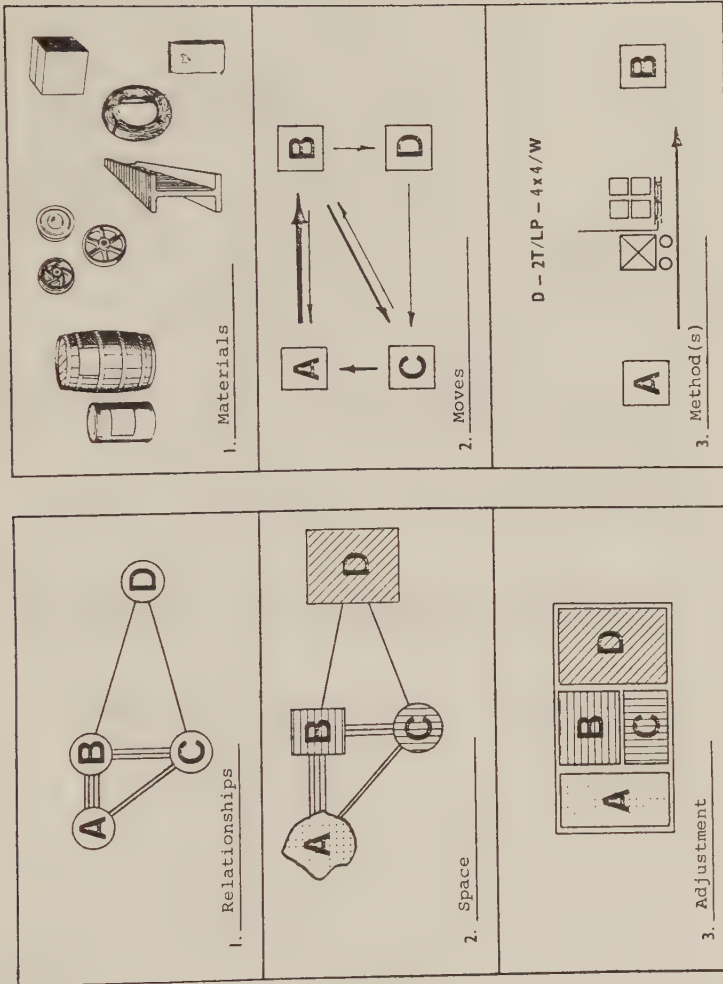


Figure 24. The three fundamentals of layout planning and materials handling analysis. (Muther & Haganäs 1973).

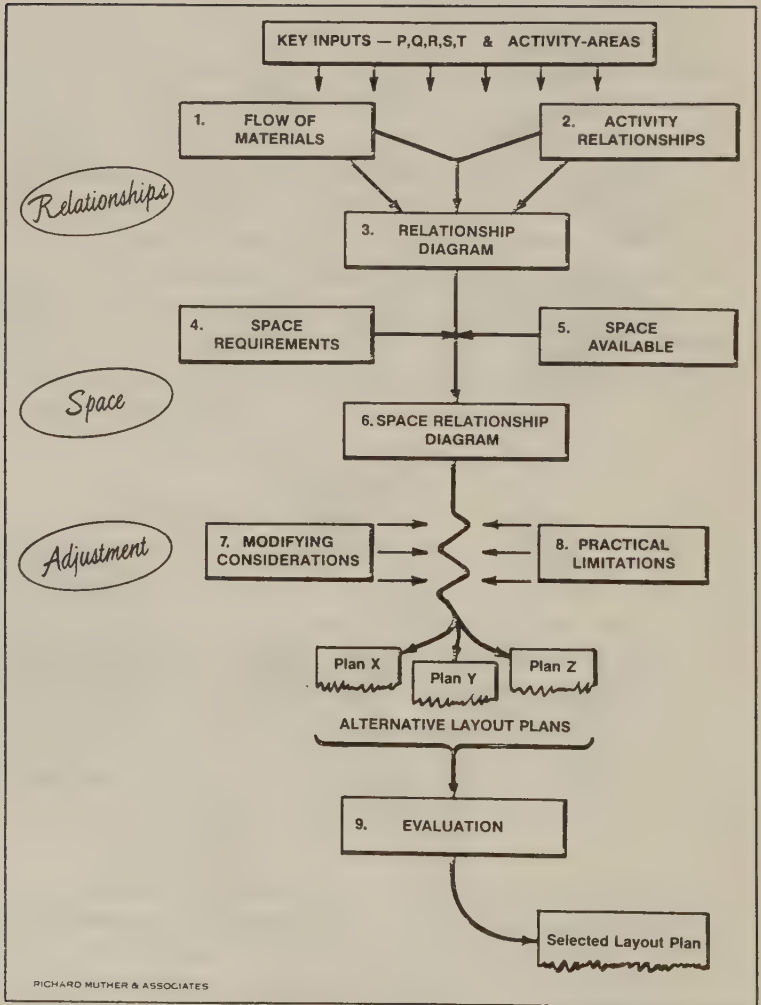


Figure 25. The pattern of procedures for systematic layout planning, SLP. (Muther & Hales 1979).

13. Last operations near shipping
14. Point-of-use storage where appropriate
15. Layout adaptable to changing conditions
16. Planned for orderly expansion
17. Minimum goods in process
18. Minimum material in process
19. Maximum use of all plant levels
20. Adequate storage space
21. Adequate spacing between facilities
22. Building constructed around planned layout
23. Material delivered to employees and removed from work areas
24. Minimum walking by production operators
25. Proper location of production and employee service facilities
26. Mechanical handling installed where practicable
27. Adequate employee service functions
28. Planned control of noise, dirt, fumes, dust, humidity, etc
29. Maximum processing time to overall production time
30. Minimum manual handling
31. Minimum re-handling
32. Partitions don't impede material flow
33. Minimum handling by direct layout
34. Planned scrap removal
35. Receiving and shipping in logical locations

8.7 Working step 7: analysis of moves

When analysing the moves, we need to have certain information. The necessary data include material and move. We also need to collect together many different kinds of data on the several aspects of each move, such as: the route over which the move is made; the volume moved; the distance with which the move is made; the rate at which the items travel, and the cost of the move.

Figure 26 includes the factors that are involved in an analysis of moves.

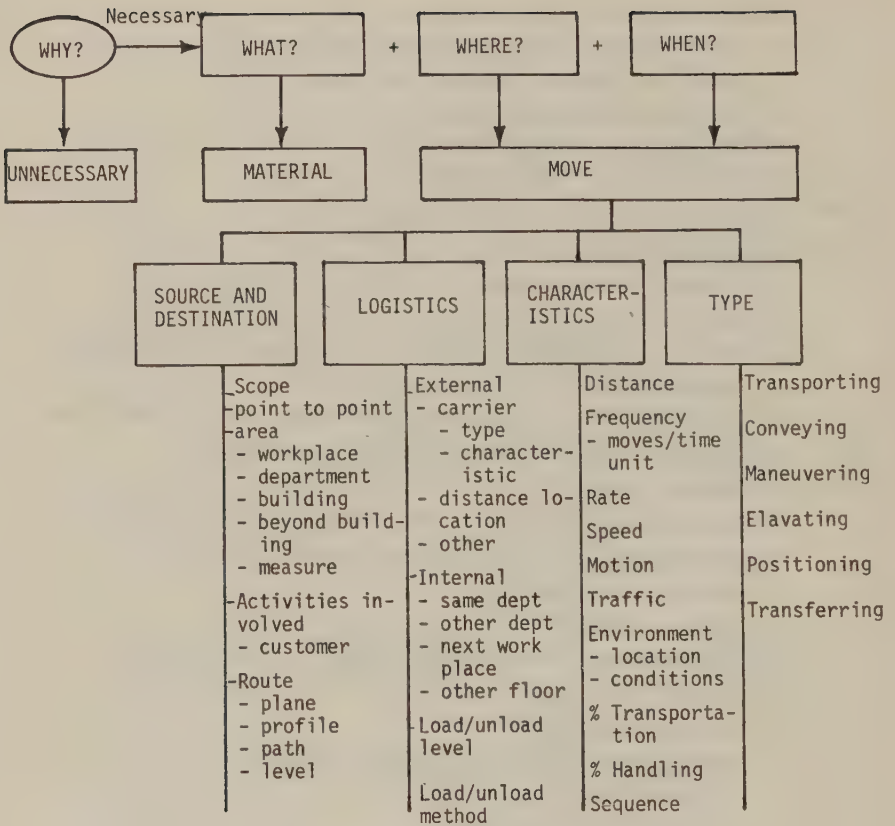


Figure 26. The analysis data of moves, or the several aspects of each move.

Process chart

The process chart is a tabular record of the steps in a process. It is one of the oldest and most common techniques for planning or analysing material flow.

Figure 27 shows a process chart. Some uses of the process chart are as follows:

PROCESS CHART				Date: 25-08-81	Name: PARASCHOS MANIATIS		
Process charted: <u>Plastics leather in a Greek tannery</u>							
Starting point: <u>Transport to Department 56</u>							
Ending point: <u>Weighting to Department 56</u>							
Quantity of Unit per (time)							
Present ☒ Proposed (Alt.) ☐ Alternative: ☐							
CHARTED UNIT (Unit of Prod., or Mat. Chart.)	UNITS PER LOAD	Activity Symbol	DESCRIPTION OF ACTION	Weight of Load Size of trips per	No: of trips per	Dis- tance in	NOTES
1. Raw-Hide	—	◻	Transport to Department 56	500kg	—	—	The raw hides are transported from the 430, 43, 50, 51 Department to 56 by a truck
2. Raw-Hide	—	◻	»	»	—	—	
3. Raw-Hide	—	◻	»	»	—	—	
4. Raw-Hide	—	◻	»	»	—	—	
5. Raw-Hide	—	◻	Operation in the paddles	—	—	—	Department 56
6. Raw-Hide	—	◻	Emptying the paddles	—	—	—	Department 56 (10 workers)
7. Hide	—	◻	Putting the hides on the cases	—	—	—	Department 56 (5 workers)
8. Hide	—	◻	The cases are carried next to the paddles	300kg	—	—	Department 56 (1 truck)
9. Hide	—	◻	Storage	300kg	—	—	Department 56
10. Hide	—	◻	Transport to the fleshing machine	»	—	—	Department 56 (1 truck)
11. Hide	—	◻	Operation in the fleshing machine	»	—	—	Department 56 (2 workers)
12. Hide	—	◻	Putting cases the edges of	»	—	—	Department 56 (2 workers)
13. Hide	—	◻	Cutting the pieces the	»	—	—	Department 56 (2 workers)
14. Hide	—	◻	Transportation to the	»	—	—	Department 56 (1 worker)
15. Hide	—	◻	Weighting	»	—	—	Department 56 (1 worker)
TOTAL				»	—	—	

Figure 27. Process chart. Process chart symbols according to Figure 3.

1. Provides a method of recording all steps in a process
2. Forces detailed examination of the process
3. Becomes the basis for analysing the process, such as in:
 - a) identifying all moves, stores, delays
 - b) pointing out improvement opportunities
 - c) showing distances, equipment, manpower, etc
 - d) raising questions about a process
4. Familiarizes analyst intimately with the process
5. Forms a basis for cost determination
6. Forms a basis for comparison of alternative methods.

Flow diagram

The flow diagram, Figure 28, is a graphical record of the steps in a process, made on a layout of the area under consideration. It is frequently used as a supplement to the process chart, Figure 27.

From - To chart

The From-To-chart (figure 29) represents one of the more recent techniques used in layout and materials handling work. It is especially helpful where many items flow through an area, such as in a large general machine shop. It is also useful anywhere there is a relationship among several activities and an optimum arrangement of the activities is desired. Some of its many uses and advantages are:

1. Analysing of material movement
2. Planning flow patterns
3. Determining activity locations
4. Comparing alternate flow patterns or layouts
5. Measuring flow pattern efficiency
6. Visualizing material movement
7. Showing dependency of one activity on another
8. Showing volume of movement between activities
9. Showing interrelationship of product lines
10. Pointing out possible production control problems
11. Planning interrelationships between several products, parts, items, materials, etc.

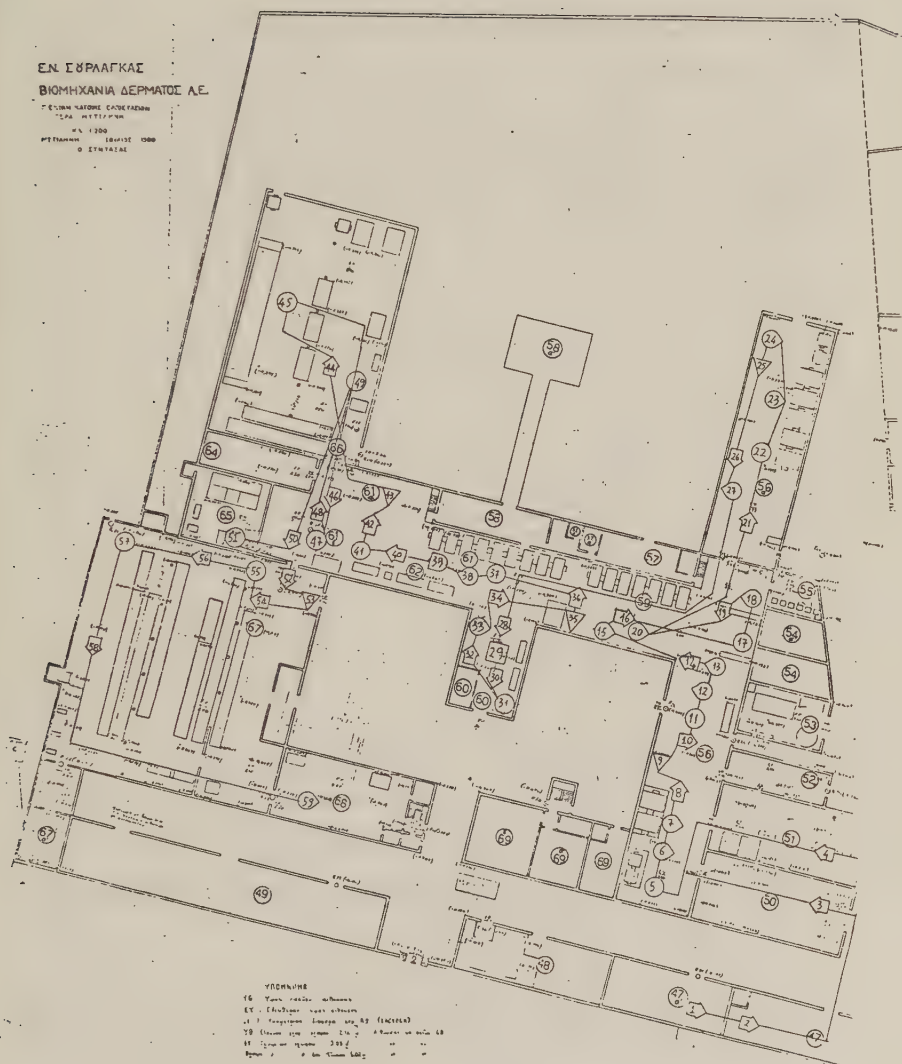


Figure 28. Typical flow diagram. The actions for the plastics leather in a Greek tannery. (Maniatis 1981).

Plant _____ Trial no. _____ Date _____ Project _____

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	TOTALS
TO (USER)																					
FROM (CONTRIBUTOR)																					
1																					
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TOTALS																					

Figure 29. From - to chart.

12. Depicting quantitative relationships between activities and the related movement between them
13. Shortening distances travelled during a process

Transport analysis diagram

It presents the most complete graphical representations of the overall process. It can be used for one or several materials or for a process-dominated sequence. Figure 30 shows a transport analysis diagram.

8.8 Working step 8: how to analyse flow

The entire flow problem arises from the need to move the elements (material, parts) from the beginning of the process (receiving) to the end (shipping) over the most efficient paths. The concept of flow through an enterprise may best be visualized by considering that each element entering the building flows through the building, following a prescribed path-planned or otherwise - until it arrives at the end of the process. Then, if each element has its own path through the facility, the composite of the several individual flows becomes the overall flow pattern for the entire enterprise.

The material flow pattern becomes the foundation for not only the basic design of the facility, but for the overall efficiency of the entire operation. It might be said that the overall success of an enterprise, or at least its profitability, is a direct reflection of the effort that goes into the flow planning.

8.8.1 Advantages of planned materials flow

A well-conceived and carefully planned materials flow pattern will have many advantages, and a good flow pattern will go a long way towards achieving several of the objectives of facilities design. Some of the advantages are as follows:

Process		Date:	Name:																
Starting point:																			
Ending point:																			
Quantity of End Unit per (time)																			
☐ Present ☐ Proposed (Alt. description of Alternative:																			
Operation	Handing	Transport	Delay	Storage	Depart-	Distance in	Time in per	Cost in per	CHARTED UNIT (Unit of Product or Material Charted)	UNITS PER LOAD	DESCRIPTION OF ACTION	Numbers of workers	Transportation equipment	The transported unit	NOTES				
									1				Name	Length mm	Width mm	Height mm	Weight kg	Eliminate Combine - Rearrange	
									2										
									3										
									4										
									5										
									6										
									7										
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									28										
									29										
									30										
										Totals									

Figure 30. Transport analysis diagram.

1. Increased efficiency of production; productivity
2. Simplified handling activities
3. More efficient utilization of work force
4. Reduced product damage
5. Reduced walking distances
6. Basic for an efficient layout
7. Simplified production control
8. Smooth production flow
9. Improved scheduling process
10. Logical work sequence

Using the master flow pattern as an overall guide will ensure that no pieces of equipment or department is located or moved without proper consideration being given to its relationship to overall flow.

8.8.2 Categories of factors to be considered in planning materials flow

- A. Material or product (volume of production, number of different parts)
- B. Moves (frequency, speed, rate, volume, destination)
- C. Handling methods (desired flexibility, equipment required, possible alternatives)
- D. Process (sequences of operations, quantity of equipment, space requirement)
- E. Building (size, shape, type, number of floors)
- F. Site (topography, transportation facilities, expansion possibilities)
- G. Personnel (number, movement, safety, working conditions)
- H. Miscellaneous (location of auxiliary services and activities, production control, flexibility, levels of activity).

8.8.3 Special requirements affecting element flow

Some activities, because of unusual characteristics, require special treatment in their relationships with the rest of the operation. Examples of types of process or activity with special requirements are:

1. Heat treating-ventilation, fire protection
2. Painting-ventilation, fire protection, heating
3. Plating-ventilation, protection against acid and fumes, electrical insulation
4. Forging-ventilation, heat removal, noise, and vibration damping
5. Foundry-heat removal, ventilation, fire protection
6. Power house-heat and dirt removal, noise damping
7. Heavy parts-facilities for material handling
8. Final assembly-nearness to warehouse or shipping
9. Inspection-air conditioning, central location
10. Precision assembly-air conditioning
11. Inflammable materials-ventilation, fire protection
12. Executive work - free of noise

8.8.4 How to visualize flow

Flow of materials may be visualized by the schematic process-flow diagram which is shown in Figure 31, where the flow intensity is proportional compared with the breadth of the flow arrows. This diagram certainly helps us understand the process flow. But it does not tie-in with layout, for it does not show each activity-area in its correct geographical location. As a result, distance is not indicated and therefore, a method cannot be selected. This type of diagram is a kind of intermediate step in analysis and interpretation.

Another way to visualize the flow is the flow diagram, Figure 32.

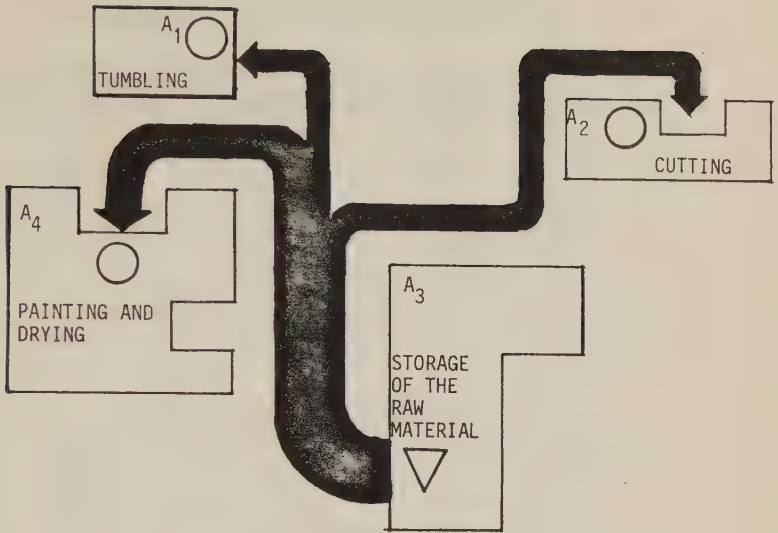


Figure 31. A schematic process-flow diagram.

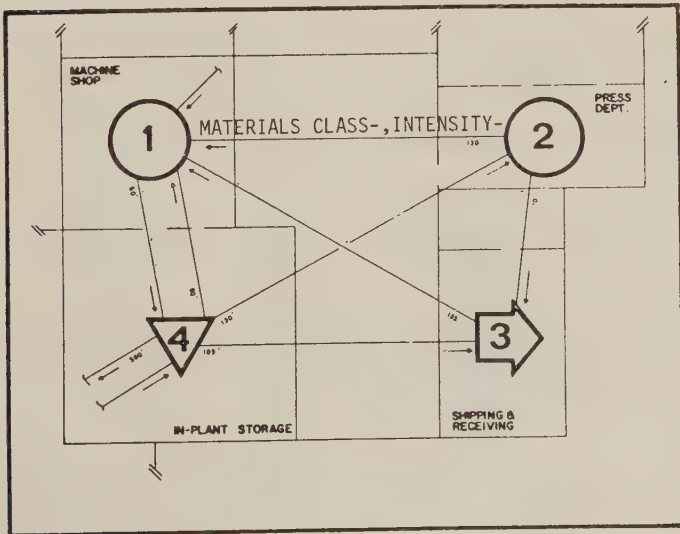


Figure 32. The flow diagram.

8.9 Working step 9: analysis for choice of load carrier

A natural consequence now is in certain cases to decide if a carrier will be used and how this shall be modelled (Figure 33).

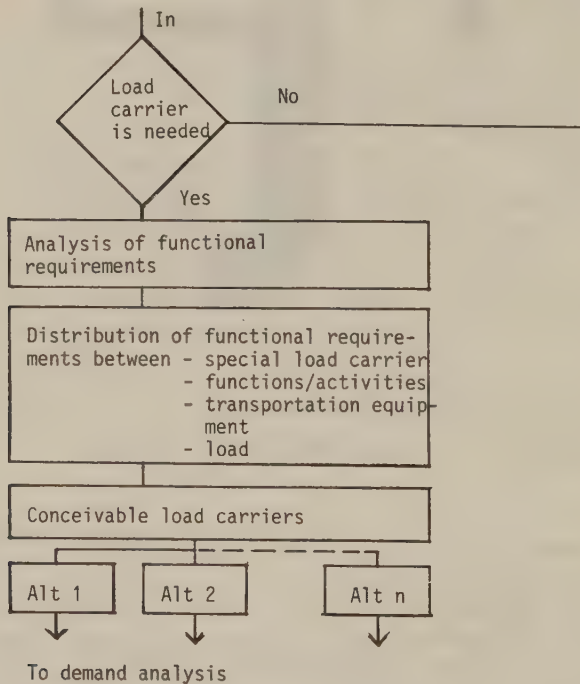
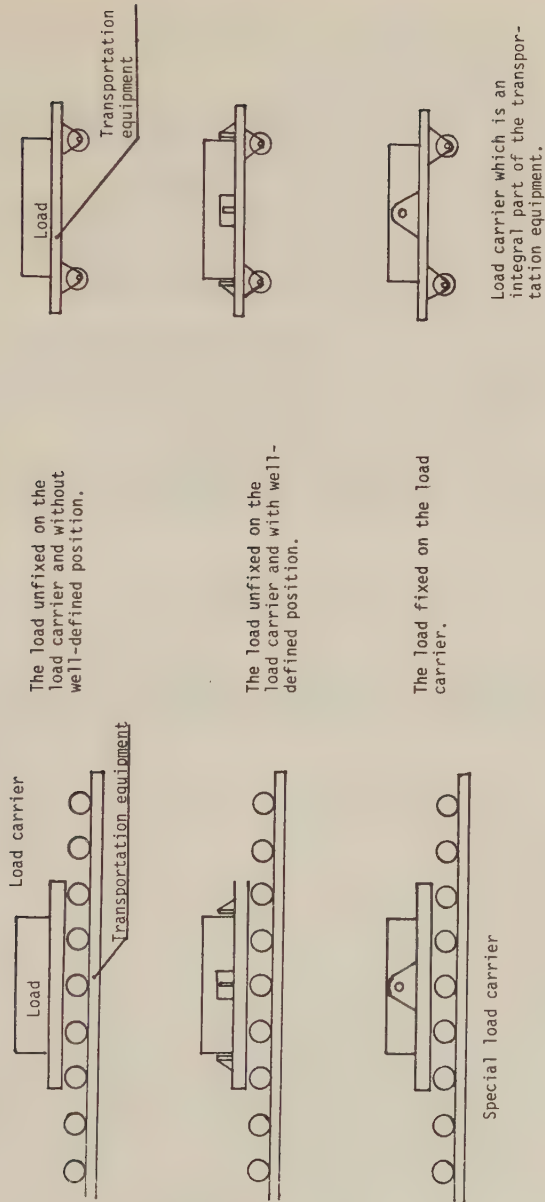


Figure 33. Analysis for choice of load carrier. (Olsson & Ulveland 1978).

Load carrier here means a loader which supports the load during removal and warehousing. Two main types of load carriers can be distinguished (Figure 34).

1. Special load carrier, which refers to a load carrier to be removed by transportation equipment, at which the load can be



Load carrier which is an integral part of the transportation equipment.

Figure 34. Different types of load carriers. (Olsson & Ulveland 1977).

- unfixed at the load carrier without well-defined position (e.g. at a pallet)
- unfixed at the load carrier but with a well-defined position
- fixed at the load carrier (possibly with a few degrees of freedom)

Further, the load carrier can be fixed or unfixed (occasionally fixed), as well as with or without well-defined position, in relation to the transportation equipment.

2. The load carrier is an integral part of the transportation equipment which removes the load, on which the load can be
 - unfixed
 - unfixed with well-defined position
 - fixed (possibly with a few degrees of freedom)

8.9.1 Is a load carrier needed?

You determine if a load carrier is needed, or if an available load carrier must be altered, by answering the following questions with yes or no.

Must the qualities of the load be improved with regard to:

- manageability
- fitness for transport
- fitness for buffer
- fitness for fixing
- accessibility
- fitness for orientation?

If one of the questions is answered with yes you proceed to the analysis of functional requirements. If all the questions were answered with no, a load carrier is not needed or the load carrier need not be altered, at which point you go straight to the demand analysis of the materials handling system/transportation equipment.

It is important to observe prospective possibilities to eliminate the demand for a special load carrier.

8.9.2 Analysis of functional requirements

The functional requirements are determined in regard to the load carrier. Here you should also pay attention to possible requirements for well-defined position, fitness for fixing and use for several other types of loads.

These functional requirements may be:

- The load carrier should be able to be lifted and lowered
- The load carrier must be able to be transported on the roller way
- The load should be fixed on the load carrier
- The load should be able to be reached and lifted from/on to the load carrier by hand.

8.9.3 Conceivable load carriers

When analysing conceivable load carriers, which comply with the required functional requirements, the following important questions at issue should be observed:

- is there a load carrier within the company
- is there a standardized load carrier on the market
- must a load carrier be constructed

which complies with the requirements?

The conceivable load carriers are valued in relation to how well they comply with all the required demands. Other functional demands are observed, for example demand for amount of investment and economic life.

8.10 Working step 10: demand analysis

In working step 10 you determine the demands for the materials handling system/transportation equipment.

This means that the following steps are carried through:

- Indicate actual demand factors
- Decide what the requesters are
- Determine the dimensions or give a demand description
- Arrange the different demand factors according to their degree of importance.

These four steps are carried through partly for the individual transportation equipment (includes factors not influenced by the number of transportation equipment in the system), partly for the materials handling system as a whole.

Two types of requirements can be distinguished:

- quantifiable (dimension and unity)
- non-quantifiable (or difficult to quantify).

The basis for determining the dimensions of the selected demands is obtained from the collection of information and pre-analysis.

To facilitate the work with demand analysis you can use the facilities "Demand analysis transportation equipment" and "Demand analysis materials handling system" given in the Working step 2.

Determination of dimensions of requirements

By asking WHY a requirement is made you can have control over the justification of the requirement as a dimensioning factor.

By asking HOW a requirement influences the choice and dimensioning of transportation equipment/materials handling system you can see in which form the requirement should be presented. This is

important both when you compare the requirements with specifications of existing transportation equipment and materials handling system and when you in Working step 16) Evaluation of alternatives decide, how well a requirement is fulfilled.

Certain requirements can be difficult to quantify and must therefore be described. This may be applicable for demands for safety, environment, flexibility, education etc.

8.11 Working step 11:knowledge and understanding of materials handling methods

A specific type of equipment, working with a specific type of transport unit, and making a pattern of moves that form a system is in reality a method (Figure 35).

8.11.1 Movement system

"System" means the way or pattern in which the different moves are tied together from both a geographical and physical standpoint. In reality, the different material can be moved separately and directly from origin to destination. This is called a direct system.

With indirect systems, on the other hand, the movements are integrated and materials moving to and from different areas are moved together on the same actual "path" and with the same equipment.

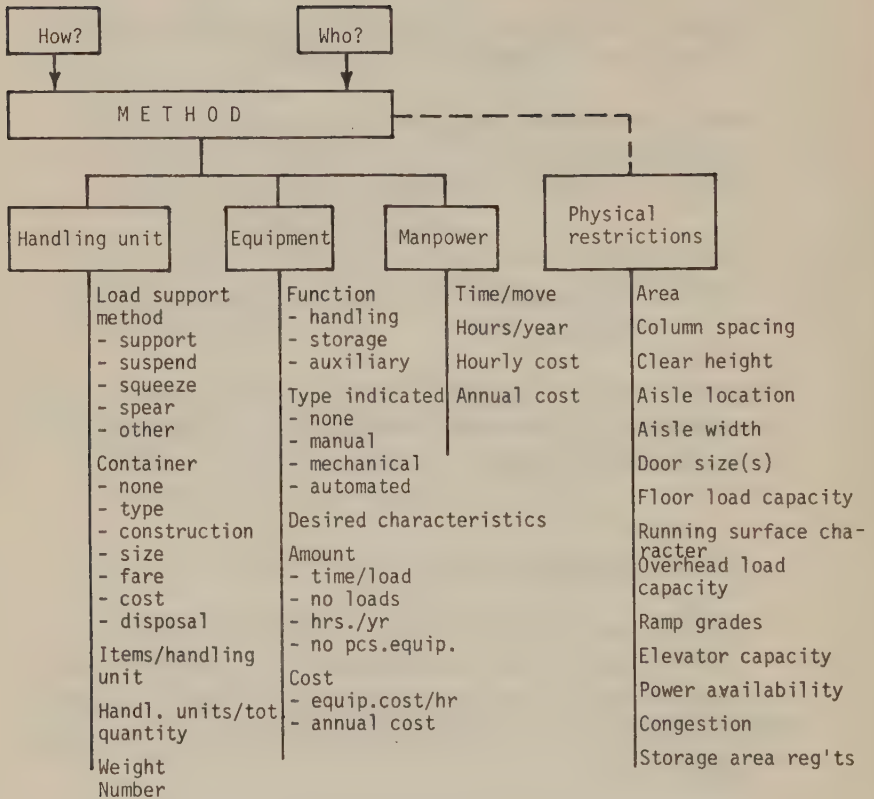


Figure 35. The pattern of the method.

Figure 36 explains the characteristics of these. Actually, there are a number of indirect systems that are similar or modifications of K and C. For example, if the kanal system returns from A_2 to A_1 directly, it forms a so-called ring system. There are two material handling cost principles which we have to remember when discussing which systems to use for different moves:

1. The principle of distance: the shorter the distance, the cheaper the move
2. The principle of quantity: the higher the quantity, the less cost per unit moved.

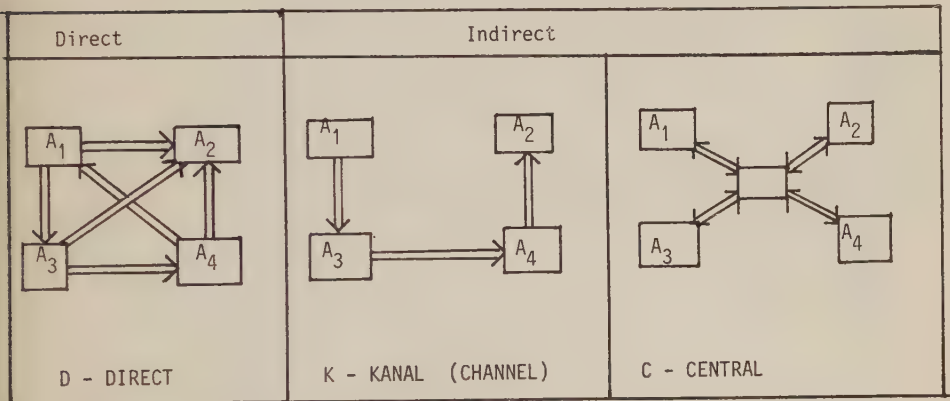


Figure 36. Classical materials handling systems.

Figure 37 shows how the distance-intensity plot can help us decide on which system to use for the different movements.

8.11.2 The place of equipment in the handling system

Equipment is not always required in solving a handling problem. Sometimes the simplest and most economical method will require no equipment at all. In fact, the work simplification approach suggests the following general procedure:

1. Eliminate the move
2. Combine the move with some other function: such as processing, inspection, storage
3. Change the sequence of activities, to shorten, eliminate, or alter the move requirements

4. Simplify the move, to reduce the scope, extent, or distance, or to improve the method or the equipment selection.

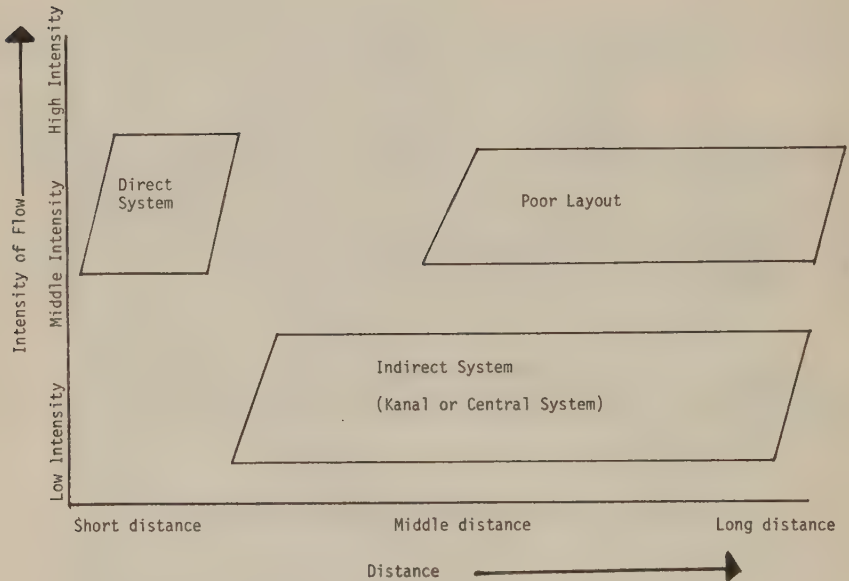


Figure 37. Distance - Intensity Plot and Materials Handling System.

The jobs tackled by materials handling equipment entail all the following:

Lifting	Holding
Moving	Releasing
Dropping	Stacking
Positioning	

The equipment used for carrying out this work operates using a number of engineering techniques and forms of energy including:

Hydraulics	Electricity
Pneumatics	Gravity

After having accomplished the above, the equipment should be selected if necessary.

8.11.3 Various ways of increasing one's knowledge and understanding of materials handling methods

It is possible to increase your knowledge and understanding of materials handling methods through:

- visits to the plants of other companies
- attendance at professional-society meetings and technical conferences
- attendance at equipment shows
- university and technical courses
- reading books and magazines
- discussion with equipment suppliers
- consultation with qualified professionals.

8.11.4 Materials handling equipment

On the basis of the British classification the materials handling equipment may be classified in a number of ways with more or less details. This British classification splits all equipment into 22 groups, the split being decided by the technical and physical features of the equipment's design (Figure 38).

Each of these basic types is further detailed in books, commercial literature and periodicals.

8.11.5 Basic handling systems

In addition to the basic types of handling equipment, there are also several so-called basic handling systems, which provide an idea of the conventional way of looking at the handling equipment problem. And it should be pointed out that the work system in

DISCONTINUOUS MOVEMENT											
LIFTING EQUIPMENT								MOBILE EQUIPMENT			STACKING EQUIPMENT
VERTICAL AND HORIZONTAL POSITIONING								HORIZONTAL MOVEMENT	LIFTING AND HORIZONTAL MOVEMENT		HORIZONTAL & VERTICAL MOVEMENT
POINT		LINE		AREA				LINE	AREA	AREA	
GUIDED	FREE	STRAIGHT	CURVED	ANGULAR	CIRCULAR	ANGULAR & CIRCULAR	UNRESTRICTED	GUIDED	FREE	FREE	UNRESTRICTED
JACKS ELEVATING TABLES ELEVATORS	CAPSTANS WINCHES HOISTS PULLEYS	GIRDER TROLLEYS FIXED GIRDER CRANES	OVERHEAD MONORAILS	TRAVELLING BRIDGE AND GANTRY CRANES	REVOLVING CRANES JIB CRANES DERRICKS	HINGED-JIB LOADING CRANES STACKING CRANES	MOBILE CRANES	RAIL VEHICLES	POWERED & MANUAL TRUCKS & TROLLEYS TRACTORS & TRAILERS	STRADDLE TRUCKS STILLAGE TRUCKS ELEVATING PLATFORM TRUCKS PALLET TRUCKS	FORK TRUCKS REACH TRUCKS STACKING TRUCKS SIDE-LOADERS

CONTINUOUS MOVEMENT										POTENTIAL MOVEMENT
CONVEYING EQUIPMENT										
TRANSPORTING					FREE ROLLING	SLIDING	PROPELLING	VIBRATING		
TOWING MECHANISM	POWERED CONVEYORS				LINE	UNPOWERED	POWERED	POWERED		
	CONTINUOUS CARRYING	LINKED CARRIERS	DETACHABLE CARRIERS	CONTINUOUS PROPULSION	UNPOWERED	INTERMITTENT	CONTINUOUS	CONTINUOUS		
										
OVERHEAD TOWLINE TROLLEY CONVEYORS IN-FLOOR TOWLINE TROLLEY CONVEYORS ROBOT TUGS	FLAT BELT, TROUGHED, CLOSED BELT, SLAT, CARRIER & CHAIN CONVEYORS.	BUCKET, EN MASSE, APRON AND PAN CONVEYORS, CROSSBAR CONVEYORS.	OVERHEAD TROLLEY CONVEYORS OVERHEAD CHAIN CONVEYORS	POWERED ROLLER CONVEYORS PNEUMATIC CONVEYORS AIR FILM CONVEYORS	ROLLER, WHEEL AND BALL TRACKS	CHUTES	SCREW CONVEYORS SPIRAL ELEVATORS	VIBRATORY FEEDERS, SCREENS, ELEVATORS	PALLETS STILLAGES STRAPPING DUNNAGE BINS HOPPERS MOBILE RACKING	
IN CONVEYORS OF THIS TYPE THE TRANSPORTING MECHANISM TRAVELS FORWARD WITH THE MATERIAL CONVEYED					IN CONVEYORS OF THIS TYPE THE TRANSPORTING MECHANISM DOES NOT ITSELF TRAVEL FORWARD					

Figure 38. Materials handling equipment. This British classification splits all Materials Handling equipment into 22 groups, the split being decided by the technical and physical features of the equipment's design. For more details, turn to the classification approved by the former AMHS (now International Materials Management Society). (Materials Handling No. 2 -- Ministry of Technology, London 1965).

this context means a group of related handling devices, commonly used in combination with each other. Materials handling systems are usually combinations of several types of equipment, which can be categorized as:

- Fixed-path handling equipment
- Limited area handling equipment
- Mobile equipment.

Fixed-path handling equipment

- Overhead trolley conveyors
- Power and free conveyors
- Floor line conveyors
- Tow line conveyors
- Belt conveyors
- Monorails
- Storage/retrieval systems
- Transfer devices
- Guided vehicles.

Limited equipment

- Overhead cranes
- Air cushioned system.

Material (load)-oriented systems are commonly identified as: unit handling systems; bulk handling systems; and liquid handling systems. Only unit handling systems will be covered here. A unit - such as a box, bale, roll of material - can be either an individual item or a number of items grouped to form the unit load.

A unit load (Figure 39) may be defined as: A number of items, or bulk material, so arranged or restrained that the mass can be packed up and moved as a single object, too large for manual handling, and upon being released will retain its initial arrangement for subsequent movement. It is implied that any single object too large for manual handling is a unit load. The many advantages



Figure 39. Typical methods of handling unit loads and various pallets and skids. (Apple 1977).

of the unit load should be obvious - but there are also some disadvantages to be considered, such as:

1. Cost of unitizing and de-unitizing
2. Equipment and space requirements
3. Tare weight of unitizing medium
4. Problem of returning empty pallets or containers
5. Transfer equipment often not available on both ends of the move.

Generally speaking the unit loads system is more flexible and requires less investment.

8.11.6 Equipment and analysis

All the foregoing leads to the conclusion that integration of the analysis and equipment for designing in-process handling systems is a must. Traditionally, perhaps because of the variety of materials handling functions, people engaged in "application" of in-process handling were one of two types:

- specialists in analysis, who were quite capable in one or more generally quantitative analysis techniques and who were looking for a problem to which they could apply their techniques
- specialists in equipment, who had a great knowledge of one or more types of equipment and who were looking for a problem to solve by the use of their equipment.

Existing transportation equipment

In a majority of the Greek industries, we meet mainly four types of materials handling equipment, namely lift trucks, conveyors, hoists and cranes.

As far as the other existing handling equipment is concerned (manual), quite frequently workers involved in the production processes are forced to leave their posts in order to help the workers who carry the equipment. This has a negative effect on the production (Maniatis 1981).

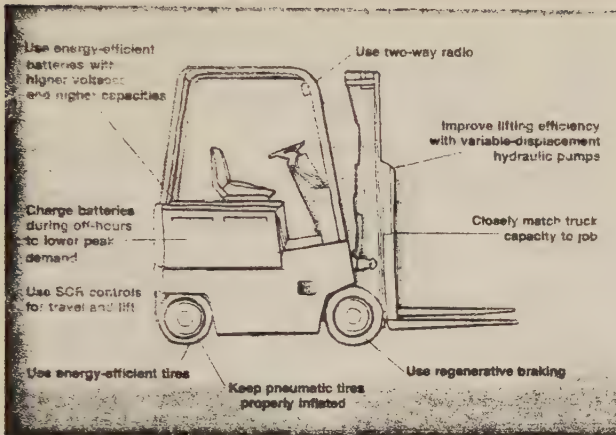
As Greek industries need to reduce the costs resulting from the functioning of the above mentioned materials handling equipment, various recommendations are given here for ways of saving energy.

How to save energy in materials handling

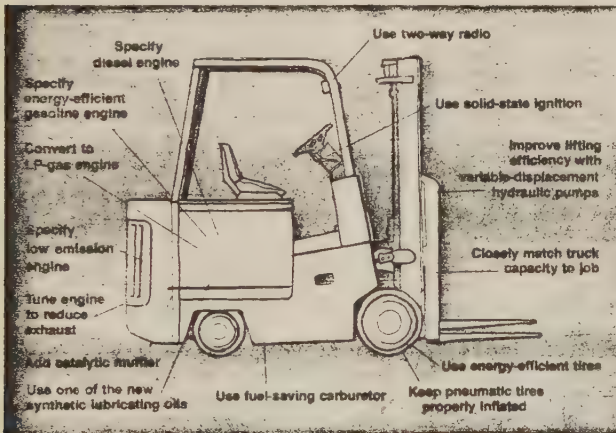
We can save energy in materials handling in two ways. We can make use of energy-efficient equipment for lift trucks, conveyors, hoists and cranes. And, we can improve the methods in our system. A vast amount of information has been introduced recently that makes the role of materials handling in energy management more important than we might ever have imagined. Here are some ideas which have come forward, and how they can be used.

Vehicles (Figure 40)

- Match the vehicle to the job - don't use large trucks for small jobs
- Maintain the vehicle yard to keep down rolling friction
- Purchase vehicles with enclosed cabs with self-contained air conditioning rather than air condition an entire area for few people
- Institute fuel accountability for each vehicle
- Charge vehicle batteries only when needed, and stagger charging times so as to avoid creating new demand peaks. Timers help, as do instruments that indicate the level of charge in a battery
- Keep vehicles turned up
- Inflate tires to recommended pressures. This saves energy and prolong tire life
- Check air filters daily
- Check levels of hydraulic fluid, transmission oil, and lubricating oil daily.



To save energy in electric truck operations, consider using equipment that permits more efficient traveling and lifting, as well as more efficient battery charging. This includes energy-efficient batteries, SCR control and regenerative braking.



To save energy in internal-combustion trucks, consider using equipment and programs that can conserve fuel and cut down on emissions. Energy-efficient engines, proper maintenance and catalytic mufflers are a few of the ideas that apply here.

Figure 40. Vehicles. (Turner 1980).

Doors

- If people enter or leave by truck bay doors, install personnel doors

- Use strip curtain doors in passages between conditioned spaces kept at different temperatures, unless there is significant pressure difference between the two areas
- Install adjustable dock cushions or enclosed bays if existing truck bays are open to outside air.

Ventilation

If ventilation is used primarily to get rid of truck exhaust, consider the use of electric trucks or vehicles with better emission characteristics.

The basic design ventilation rates for fuel-powered lift trucks are 5,000 cfm per propane fueled lift truck and 8,000 cfm per gasoline fueled lift truck, with more depending upon maintenance conditions, operating time of trucks, volume of space per truck and truck horsepower.

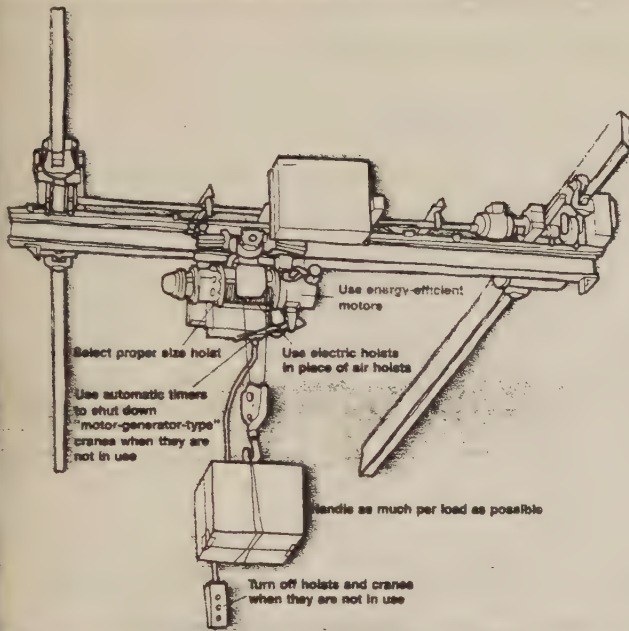
Hoists and cranes (Figure 41)

- Use electrical hoists and cranes in preference to those powered by compressed air (5 hp on compressor = 1 hp on hoist)
- Use time delay switches to turn off crane motors when not in use for present period (5-10 minutes)
- Package in large unit loads to reduce number of moves
- Turn off hoists and cranes during off hours as part of usual closing list.

Conveyors (Figure 42)

- Install controls to turn off conveyors when not needed
- Consider wiring conveyors to turn off when area light switch turns off
- Install and update preventive maintenance program for motors. Check motors routinely for bearing wear using an industrial stethoscope.
- Active end (if a belt or chain drive is being used) should be 2-3 db louder than fixed end.

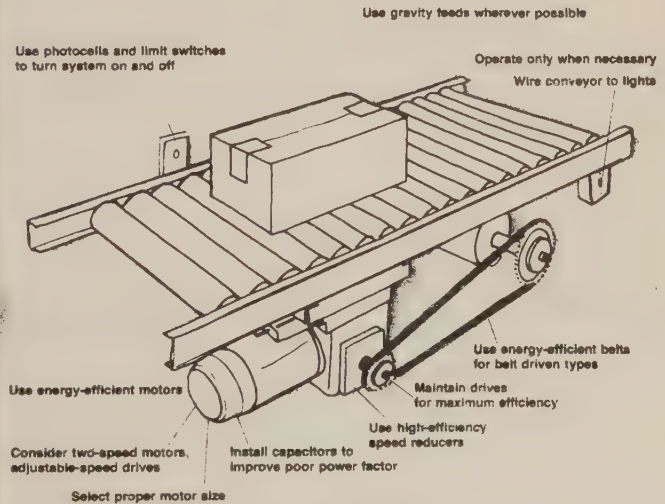
Figure 41.
Hoists.
(Turner 1980).



Energy-saving hoists and cranes, like conveyors, should have energy-efficient motors and components that are properly sized and easily turned off when not in use.

Figure 42.
Conveyors.
(Turner 1980).

Energy savings in conveyors come from equipment that improves the performance of the motors and drives, as well as from the proper selection of belts, switches and conveyor types.



8.12 Working step 12: preliminary handling plans

8.12.1 Methods shown on ordinary worksheets

One way we can set down our plans is to record them on a worksheet. Figure 43 shows a simple way listing the systems, equipment, and transport unit for each material (or material class) on each route. When there is only one or a few materials and a straightforward sequence of routes, this is a practical way to go. Another way that we can do this is to record right on the previously made process chart for a proposed change in method (Figure 27).

8.12.2 Methods on tie-in sheet

When there are many routes and many material classes, the "tie-in sheet" is usually the most practical way to record the proposed methods. Figure 44 shows the tie-in sheet. Each route has one line and each material class has one column.

For each move (one material on one route) there is space to record, the intensity, the proposed system, equipment, transport units and time, using the same coding symbols already described. The tie-in sheet has space available for other information also, such as alternative methods, time calculations and equipment utilization.

8.12.3 More than one plan

We usually make a number of preliminary plans. In the next steps of the model, the different plans will be modified, screened, and improved.

MATERIALS HANDLING METHODS WORKSHEET				Plant	Project	
				By	Date	
	ROUTE FROM (Trpt symb.)		TO (Trpt symb.)	MATERIAL	PROPOSED METHOD System, Equipment & Transport Unit	REMARKS
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
	Note:					

Figure 43. Materials Handling methods worksheet.

8.13 Working step 13: modifications and limitations

In every materials handling plan certain modifications and limitations are always involved. These are indicated below:

1. The production requirements today and the long-range plan for expansion and/or change
2. The integration with the production process or process equipment
3. The utilities and auxiliary services that are available or that can be provided to support the handling plans
4. The layout or tentative layout plan proposed and its space limitations (amount, kind, and configurations)
5. The buildings and their structural features
6. The storage practices and the methods and equipment for storing materials.

If we have a long distance and the intensity is high, it indicates that we may have a poor layout. Changing the layout becomes a very important modification. First, a change in layout is not a part of the materials handling analysis. Basically, shortening distances is a layout problem, quite often involving different people in the planning and involving the operating and service people in greater depth or in a more serious way. Second, changing the layout causes us to go back in our pattern of procedures and re-do the steps 6,7, and 8.

8.14 Working step 14: calculation of requirements

8.14.1 Analytical way

Having modified our preliminary handling plans, we now are ready to specify and calculate those alternative plans which we feel are most realistic. Generally, we want two to five alternative plans, and for each of them we have to:

1. Specify the methods for each material on each route

For rough specifications of handling methods, we may use the same procedures as in step 12 (Preliminary handling plans).

2. Explain any necessary changes other than in handling methods, like changes in layout, scheduling, process, buildings, utilities, and roadways

In parallel with clear specifications is the need to recognize and record other changes.

If, for example, the building structure has to be strengthened before installing a bridge crane, this must be included as part of the installation, the investment cost, and consequently the specifications of that alternative method. Similarly, if improvements in inventory reporting and recording are necessary as part of a proposed new method of storing and order-filling finished goods, then that change in inventory control must be included in the alternative.

3. Calculate the equipment and manpower required

When calculating equipment and manpower, we must be aware of the fact that the materials handling plan will have to operate under a number of different conditions. In many cases of analysis, we determine the intensity of flow under average conditions. When calculating the equipment, we must realize this and make adequate the provisions for maximum lifts, worst conditions, and seasonal conditions or peakhours. Depending on the nature of the problem, we sometimes make two sets of calculations for each material handling plan, one for the average condition and one for the maximum requirements.

Another factor that influences the accuracy of our calculations is the degree of equipment utilization. For a variety of reasons, handling equipment normally operates at a level well below its full potential utilization time.

When calculating the equipment the following logical questions should be answered:

- Should equipment work two or three shifts?
- Should it continue to operate during lunch breaks?
- When do we service or maintain the equipment?
- Is equipment idle when the operator is getting on or off?
- What stand-by or other protection is required in case of equipment break-down?

The items below should almost always be considered:

1. Number of shifts
2. Maximum and average operating conditions
3. Maintenance and break-down time
4. Personal time for operators
5. Get-ready, shut-off, and clear-up times
6. Scheduling and planning time
7. Time for travel empty or return empty
8. Waiting, synchronization, or delay-in-production time
9. Actual versus stated (or rated) capacity (time and load factor)
10. Consolidation of stock, removal of scrap or waste, handling rework materials or empty containers.

4. Calculate investment and operating costs

1) Investment requirements

This includes:

Capital-expenditures (materials handling equipment, auxiliary equipment, building alteration cost, etc)

Expenses (moving cost, preparation cost, running-in cost, etc)

Working capital (raw materials inventory, finished goods inventory, work-in-process inventory, and the like)

2) Operating cost

a. Fixed costs

- 1) Capital cost (interest on investment, depreciation)
- 2) Other fixed cost (supervision, insurance, floor space rentals, etc)

b. Variable cost

- 1) Equipment variable cost (power, maintenance, spare parts etc)
- 2) Labour (direct labour, fringe benefits, etc).

8.14.2 Simulation of Internal Transportation Systems

Simulation can be divided into two main categories: Continuous simulation and discrete simulation.

Continuous simulation requires a construction of a mathematical model over the system studied. Both its relations with the environment and conditions and relations within the system itself must be clearly determined in mathematical terms. Continuous simulation technique is selected if you are interested in studying the time in which different flow patterns are changed, the behaviour of the variables in a certain system as well as how the changes in variables influence each other. In general, continuous simulation is based on use of differential equations. Special, usual programming languages for this type are DYNAMO and CSNP.

Discrete simulation is in principle done in that way, that you move a number of transactions (e.g. material to be handled) through a number of processes, in which different activities take place. This type of simulation is used e.g. if one wants to know the degree of utilization of different processes, the speed of move for a certain transaction, the cues that arise in the system as well as how a certain system should be dimensioned in different respects to carry out the tasks in a satisfactorily way. Discrete simulation resembles much conditions on a production line where you first determine the coming patterns for the different types of goods to be handled and then let these be moved gradually through the production process and its different activities, each of which has its parametres and its characteristic behaviour. Discrete simulation can be event or particle orientated.

Simulation can shortly be described as a mathematical-statistical technique with the capacity to describe, explain and forecast an observed system's behaviour without engagements in the real system. In the simulation technique models of the observed system are used. No direct requirements are made, how comprehensive or complex a model must be or how it will be described. Stochastic elements can e.g. be entered in the model. The disadvantage concerning simulation is that an optimal solution will not be obtained or in any case not guaranteed. However, by experimenting with the model and trying different handling alternatives and varying incoming factors you can get an idea of how the real system behaves under different conditions. In this way you can find a "best" alternative among a certain selection.

A way to get an optimum is to try all the conceivable handling alternatives. This is often unconceivable because of the great number of possible combinations and the costs associated with the computer running. The goal criteria, according to which the solution will be valued, are often difficult to compare and conflicting. As to a materials handling system you may want e.g. to obtain the biggest possible capacity at the lowest possible cost, at the same time as the workers' requirements for convenience, comfort etc must be paid due attention to. It means that it is not only difficult to show that a solution is optimal, it may even be difficult to show among alternative solutions which one is better than another one.

Of this you must not make the conclusion that simulation is an expensive technique that does not solve any problems. In many cases it is the only conceivable way to analyse a certain complex system under different conditions.

Other reasons motivating the use of simulation may be:

1. Simulation makes it possible to study and value the effect of different engagements in a real system. In that way you will get knowledge and comprehension for the real system's

behaviour. You also will get information of which variables are most important and how different variables influence each other.

2. A certain system can be impossible or in any case extremely expensive to observe or to experiment with in reality.
3. The observed system is so complex that it is almost impossible to describe it with the help of a number of mathematical equations, from which it is possible to obtain analytical solutions, which could be used for forecasting purpose.

In other cases you can find mathematical expressions which cannot, however, be solved in the usual way.
4. Simulation can be used to test solutions produced in a conventional way, or to prepare measures at the prospect of new conceivable situations.
5. Valuation of alternative system constructions can also constitute an important reason.

It may be appropriate to point out that the advantage of simulation must always be compared with what you can produce with conventional methods and at what price. A part of this process is made by the time consumed between the formulation of a problem and the presentation of a ready result. Simulation acquired by experience can be both time and cost consuming, especially during the initial period.

Phases of a Simulation Project

If a simulation project will have presumptions to succeed it must be carefully controlled and supervised all the time. In every step of the project new decisions must be made in order partly to obtain relevant results and partly to keep within the scope of time and cost put forward as a condition.

A simulation project can in principle be divided into the following, overlapping phases:

1. Formulation of problem and aim. Limitation of range
2. Relationship scheme
3. Shaping of model
4. Collection of information
5. Programming
6. Validity
7. Computer running
8. Interpretation of solution. Suggestions for measures
9. Installation. Follow-up.

The contents and the extent of the different phases are partly dependent on the character of the simulation project and the company's experience to work with this technique. What the phase should contain in general, is discussed below.

1. Formulation of Problem and Aim. Limitation of Range

This phase is very important because here you must decide the extent of the project and weigh its need of resource in regard to time and costs against the expected profits or decreased risks it can give rise to. The aim of the phase is to bring about:

- a clear definition of the problem
- a limitation of the range of problems
- formulation of aim, preferably in operational terms as well as arrangement of decision criteria that make it possible to estimate when satisfactory results have been obtained and the simulation thus can be completed
- an estimation of what factors influence the solution of the problem and what data can be needed
- analysis and estimation of conceivable methods to study and solve the problem
- model of ideas
- estimation of conceivable and expected profits economically and in other respects
- time-planning and planning of need of resource

This first phase in the simulation project must not be made too detailed or too comprehensive. Instead, you should aim at width in layout and possibilities of alternative views and methods of action.

2. Relationship Analysis

In the phase Relationship Analysis you start the work with the more concrete shaping of a model possible to manipulate. Starting from the idea of the model under work you divide the problem into suitable blocks. From this you gain good surveyability, a simplified analysis and a more flexible computer program. The most important components and variables of the respective blocks are defined and the relationship between them is explained.

It is very important that the presented relationships are correct and that no important relationships are forgotten. In an existing system, special investigations are often required to explain the relationships. If there exists no system at the present moment, hypothesis of relationships must be presented, if possible, based on previous experiences from similar systems.

The presented relationships are often expressed in the form of functions of distributions. Validity of relationship functions is important and should preferably not be made with the help of empirical data. Corresponding process is valid for relations between the blocks. The result of this phase can many times motivate a deeper analysis of goal variables and a modification of presented criteria for valuation of results. The number of goal variables should, if possible, be kept down. A point of aim should be that you make an one goal variable in the experiment to try to optimize or to obtain satisfactory values. If several goal variables are necessary you can try to set up a collected goal (or utility) function.

The level of flexibility and degree of details for the final model must now also be made clear. Several reasons speak in favour of the fact that the model, in any case in its first version, must not be made too full of details.

3. Shaping of Model

The shaping of a model constitutes a direct continuation of the relationship analysis by the way that you, step by step, shape the model in details, according to the model sketch produced previously. The appearance of the model is to a great extent dependent on the character, size and complexity of the problem to be simulated, what programming language will be used, method for time-writing of actions in the model etc. Also because the shaping of the model takes place as a trial and error process it is difficult, but desirable, to set up a scheme on how it should take place.

At the shaping of the model you try, starting from a description of the real existing or planned system, to reduce this to a flow diagram, the components of which are mathematical or logical relationships.

One of the first difficulties that crop up is how many and what variables will be included in the model. A greater number of variables increase the complexity and make the computer running more expensive to a great extent. On the basis of the produced result variables you have, without the real system, to try to identify the variables that most significantly influence the result variables. In general, a very small part (maybe less than 10%) of the total number of variables in the real system correspond to a very great part of the result (maybe 90%). It is then very important that the right variables and the right relationships between them are really included in the model. The success in the shaping of the model is largely dependent on the experiences of the simulation technique, the knowledge of the real system, and the ability to think creatively.

At the shaping of a model you must also decide the programming language, methods for time-writing and methods for random-number generating.

4. Collection of Information

The collection of information is no limited phase but is begun already during the formulation of the problem and the aim, and is then intensified because of the increased need of information. One reason to start the collection of information in good time is that otherwise the simulation work can be delayed because of the time the collection of information requires. In principle, the collection of information should be clear at the same time as the shaping of the model so that the programming of the model is not disturbed.

In connection with the collection of information there are some factors worth pointing out:

1. The importance of the fact that you really obtain relevant information.
2. It is not only current information that is interesting, but also information concerning the future because it is then the transportation system in question will be used.
3. A materials handling system must be adapted to the occurring variations in the load. That is why you can not only count with mean values concerning e.g. numbers of goods and transportation frequencies, you must also have a size of variation, e.g. in the form of standard deviation. By determining the desirable service level you obtain the capacity requirements for the system.

5. Programming

Programming of the model can be performed in different languages, each one with its special advantages and disadvantages. The choice is between special simulation languages, e.g. GPSS, SIMULA, and SIMSCRIPT, the usual problemorientated languages, e.g. FORTRAN and ALGOL, and a machineorientated language.

The simulation languages will bring a considerably easier and quicker programming work while the problemorientated languages will require less for the storage location and machine-handling time in the computer, at the same time as you have greater possibilities and freedom when shaping the programs.

An important goal when programming is to make the program flexible. The reason is that gradually, while the simulation proceeds, you get results that show what happens during manipulation of the model in different ways and that also can initiate changes in the program.

The choice of programming language should also be influenced by the fact that when simulating a materials handling system you mainly work with logical operations and the complicated mathematical calculations are comparatively uncommon.

6. Validity

Validity means that you investigate whether the model - with regard to the purpose of the simulation - is a real representation of the real system and if it gives realistic results. Validity is naturally a comparative conception. You should aim at empirical validity, that is through measures in the system verification of the assumptions the model is based on. Many times you are, however, forced to more subjective estimations of the ability of the model to describe reality. Validity is then estimated by exposing the model to tests of different kinds, e.g. of a statistical nature. There are no general methods for validity.

Validity is a process that proceeds during the whole simulation project and every phase in the shaping of the model should, if possible, be validated. As a matter of fact, it is only a realization of the results of the simulation that more certainly can show, if the model is valid or not, because the aim of the simulation is to learn the consequences of new handling alternatives.

7. Computer Running. Experimenting

A simulation model includes a number of different variables between which there exist more or less complex relations.

The number of possible combinations of value in different variables is in general very great. The course to be studied is dynamic.

A simulation model does not in general give any direct solution to a certain problem. All these factors mean that a comparatively long run with the computer is required, which is why the experiment must be planned well.

The aim of the experimenting must also be clearly determined. In general, it makes a combination of goals between the following extremities:

1. To find the optimal solution to a certain problem
2. To obtain greater knowledge of the real system.

In general, a simulation model contains several result variables. The difficulty then is to value every experiment with regard to its values. In those cases where you can make up a list of importance functions, the problem is solved, but in general the results must be valued intuitively, or with the help of previous experiences of the system. You can often also give the most result variables acceptable values, at which the problem is reduced to these being as subconditions, to maximize or minimize the rest (preferably one).

Searches for variable values that possibly will give better results are in general made through a valuation of result variables after each experiment. This method can, however, involve difficulties in showing that you have achieved an optimum or equivalent at the end of the simulation.

In most simulations different quantities or average values are measured, e.g. qualifying period in a cue. Reliability in results is then to a great extent dependent on how big the selection was, the duration of the simulation, the time scale chosen, the number of experiments performed as well as how often the values of the actual variables have been observed. The bigger the selection, the longer duration for simulation etc, the greater probability for a correct result. Another method to increase reliability is to make more runs over the same period with different sets of random numbers or to use special statistical methods that reduce the faults in results.

8. Interpretation of Solution. Proposal for Measures

To make a simulation model manageable it must be based on a line of assumptions, a selection of influencing variables and simplified relations between these. A regard to this must be taken when the results of simulation will be interpreted and valued. So far as you can not compare real and generated courses with statistical reliability, this phase gives space for a number of more or less subjective judgment.

The proposals for measures the simulation results in are of course influenced by this. Because the simulation project in general is just a part of a bigger complexity of problems, you have to put the results of it into its connections, before any proposal for measures can be made that support the result of the simulation. Otherwise you risk suboptimizing. It is also worth pointing out that result valuation is not static. You must be prepared for the possibilities of both errors and changes in the system.

9. Installation. Follow-up

A simulation project is not completed when the simulated system has been installed, the proposed changes have been made or when you have learned enough about the system. A follow-up of the result should also be made both in order to control and to collect experiences for future projects. This is more justified for a simulation project than for others because the field is quite new and inexperienced. In models for continuous use you can expect a recurrent revision, as the real system is altered.

8.15 Working step 15: alternative handling plans

The calculation of requirements leads us to our final alternative plans. Each plan has to be presented so that it is easy to understand and has all major features specified. All the modifications and limitations will cause adjustments in the handling plans originally conceived. As they do so, any changes of merit should be recorded.

8.16 Working step 16: evaluation of alternatives

The alternative systems and equipment are valued with regard to how well they meet with the requirements made.

Recommendations:

1. That each materials handling plan be titled and identified
2. That it be clearly specified
3. That it be integrated with the layout
4. That it be supported with clear worksheets and calculations.

The evaluation process generally involves three different types of analysis:

8.16.1 Technical evaluation of quantifiable factors

The quantifiable technical factors are valued according to how well they comply with the stipulated requirements considering their mutual importancy, to which the alternatives are compared.

8.16.2 Evaluation of non-quantifiable factors

The alternatives are compared with regard to the non-quantifiable factors, which includes comparing advantages and the weighted-factor analysis.

Apart from realistic cost figures, every project of handling analysis also involves intangible factors or considerations. In fact, it is surprising for some analysts to realize that the final selection rests on intangible considerations as often as on cost comparison.

These intangible factors or considerations vary from project to project in their incidence and their relative importance. And, of course, each alternative plan rates relatively high or low

on each factor in comparison with other alternative plans being considered.

The factors, other than direct measurable costs, which are most commonly involved include the following:

1. Integration with and ability to serve the process operations. Many suggestions were taken into consideration from various industries abroad, for the sale of necessary equipment which is suitable to cover the operation need of the industries.
2. Versatility and adaptability of the handling methods to day-by-day fluctuations in products, quantities, and delivery times.
The customers desire flexibility in the change of their orders during the process time and actual time of delivery.
3. Ease of future expansion of the handling methods.
4. Limitations imposed by the handling methods on the flexibility and ease of expansion of the layout and/or buildings.
5. Space utilization.
6. Working conditions and employee satisfaction. The working conditions may be bad since there is no ventilation. Place for break is not available.
7. Ease of supervision and control.
8. Ease of maintenance and rapidity of repair.
9. Availability of transportation equipment needed. The usual type of materials handling equipment exists on the Greek market (lift trucks, conveyors, hoists and cranes). The recommended equipment must be suited to the workers' mentality (no robots, no driverless trucks). They must be able to abolish the manual work, increasing in this way the mechanization. They must be able to transport many kinds of products.
10. Personnel problems - available workers with proper skills, training capability. As only the usual types of materials handling equipment exist on the Greek market, schools for

training truck drivers do not have the capacity to train truck drivers for special types of equipment.

11. Tie-in with scheduling, inventory-control paper work.
12. Potential delays from required synchronization and peak loads.
13. Supporting services required. The service for unusual types of equipment is difficult to get. The spare parts are expensive.
14. Integration with storage facilities. The storage time is long because no storage technique exists.
15. Availability of capital or investment money. The industries are not disposed to the buying of expensive materials handling equipment. In certain cases, however, it is possible to reserve money for purchasing of expensive materials handling equipment on the presupposition that the concrete equipment will reduce the materials handling costs to a large extent.

8.16.3 Weighted-factor analysis

The evaluation of factors is usually done best by the weighted-factor method of comparing alternatives. This method is explained in Figure 45.

8.17 Working step 17: selection of alternative

The system and the transport equipment are selected which, starting from the valuation, are estimated to comply best with the requirements.

The system selected may affect or be affected by the environment. This should finally be investigated.

EVALUATING ALTERNATIVES

Project		Date		No.			
		Ratings by					
Weight set by		Tally by					
A Description of alternatives							
B							
C							
D							
E							
FACTOR/CONSIDERATION	WT	RATINGS/WEIGHTED RATINGS					COMMENTS
		A	B	C	D	E	
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
TOTALS							
NOTES		Evaluating Description A = Almost Perfect-(Excellent) = 4 E = Especially Good-(Very good) = 3 I = Important Results Obtained(Good)=2 O = Ordinary Results-(Fair) = 1 U = Unimportant Results-(Poor) = 0 X = Not Acceptable-(Not Satisfactory)=-1					

Figure 45. Evaluating alternatives.

9. SUGGESTIONS FOR GUIDING PRINCIPLES OF DEVELOPMENT

9.1 Future requirements of materials handling transport systems

Because the future requirements of a materials handling system can only be foreseen partially, quite a high degree of flexibility is necessary. When it is a question of modifying a system for future needs one must not "wait and see" what changes will happen. The system must be planned for conceivable changes. One must try to make clear what measures must be taken immediately and to identify what really important co-operating factors must be taken into consideration for the future. It is also suitable to modify the system to influence future needs and conditions for an optimum system.

A simple method of foreseeing the future is to study how the development has been before and then extrapolate forward. Technical development has, however, been moving very fast recently, at the same time as "man" and "the environment" has begun to attract more interest, therefore it is justified to consider if the future in all respects will really constitute a simple extrapolation of the conditions of today.

9.2 Optimizing materials handling system

To optimize transport system we must not forget to put the problem into its connection, which means we must consider the whole transport chain from supplier via factory up to the ultimate consumer.

A classification of the methods used to assist in the selection of an optimum materials handling system is:

1. General advice and instructions with the help of which a more comprehensive and better selection can be made.

2. Different forms of check lists to be followed when selecting a system and/or components.
3. A kind of decision model where the "right" transport system will be achieved step by step. Auxiliary means for the selection are also mentioned.
4. Selection with the help of computer technics. It can be thought then that technical and economical data for different types of transport equipment have been stored and that a program has been constructed which selects a materials handling system with relation to the requirements. These requirements are used as input to the computer. The proceedings can also be carried out quite manually so that punched cards with requirements are compared with punched cards which denote characteristics of different equipment.
5. Operation analytical methods, mathematical formulas etc. They are generally used to optimize partial problems and lead to suboptimization. In order to make the problem of selecting a materials handling system mathematically manageable, quite a lot of simplifications must be carried out.

A number of computer programs have been developed for some of these methods.
6. Simulation models, almost unexceptionally modified as computer programs. Generally they have been developed by a certain industry and adjusted to its special requirements and problems and are thus not generally usable without special proceedings. Programs have also been developed at some institutes of technology (among others at the Transportation and Materials Handling Engineering Department of Lund Institute of Technology) and at universities.
7. Rest.

9.3 General advice and instructions for comprehensive and better selection

More or less modified and particular instructions and advice for an optimum selection of materials handling system are to be found in specialist literature. Study literature for transport engineering at the Transportation and Materials Handling Engineering Department, Lund Institute of Technology, is in certain respects characteristic in this matter. It is underlined among other things that "there must, as a foundation of an effective transport planning within an industry, be a thorough analysis of the different transports. It is a question of having the best possible adjustment of transports to the chain of production or distribution which they are part of. The aim is a manageable optimum" (Bjerner 1981). The importance of the latter can hardly be overemphasized. There are often examples of suboptimization both in theory and in practice.

When analysing transport problems there are a number of questions of standard character to be asked:

1. Is the transport necessary?
2. Can a more favourable transportation route or storing place be selected?
3. Can greater quantities be transported at one time?
4. Can continual transport be applied?
5. Can the goods be better adapted to the transport?

This list can naturally be extended considerably and also take the form of a check list to go through point by point for every transport. One should not be satisfied with asking the above-mentioned questions just once, e.g. at the beginning of an analysis work. They should constantly exist in the subconscious, and a final control should be done.

Different auxiliary means, e.g. in the form of transport diagrams and flow process chart, which should be used in transport analysis that institutes the work by selecting a transport system, belong to the basic education in transportation engineering (Bjerner 1982).

Advice and instructions for the selection of materials handling system can be classified according to different types of system:

- a) Instructions regarding which factors are important to be treated by the selection.
- b) Instructions regarding which working moments should be carried through by the selection.
- c) Rule of thumb with regard to when and where a certain type of transportation equipment is suitable.
- d) General principles or decision rules for the modification of the system.

9.4 Work environment

One factor which has been given too little attention too long is work environment. Trucks are allowed to give off poisonous exhaust gases and noise, conveyors are allowed to make noise and operate without sufficient safety measures to prevent personal injuries, no straight demands are made upon the education of transport workers, insufficient measures are taken to prevent back injuries caused by incorrect working positions and heavy lifts, goods receiving and dispatch places are draughty and cold, transport workers' need to communicate often means that the demand for ear protection is neglected etc.

In certain cases the problems can be solved with the help of mechanization and automatization, e.g. by using robots in disadvantageous work environment, such as intense heat, cold, poisonous atmosphere and radiation or because of hard and monotonous work. In other cases a different selection of power source for the transport equipment may be necessary, isolation of the source of noise, redesign to increase safety, education of truck drivers or even a completely different selection of materials handling system may be an appropriate action.

9.5 Trends

No matter how uncertain a judgement concerning the future might be, it must still be made. If it is not too long-range, the best method is probably to identify trends, estimate these and try to push them forward in time. Often the trends are not of a general character but can be applicable to a certain branch, a certain geographical region, a certain type of equipment or something else. Neither are the trends always distinctly or economically or logically motivated.

Examples of trends are:

1. Escalation

Because of increased production, better assortment and higher door-to-door rate in production, greater demands are made upon the capacity of the materials handling system.

2. Mechanization

The trend towards mechanization is very much commented. The reasons are partially the same as for the escalation trend, but other factors such as high wage costs, sharpened demands on operation and control and also increased knowledge of the important roll of the transport system in the production process must be considered.

3. Regard to the work environment

The great importance attached to work environment finds many expressions.

Problems of exhaust gases and noise lead to changes from combustion motors to electric motors for truck operation. Efforts to decrease the physical stress of labour force bring increased demands for improvements in handling facilities. Demands for safety, comfort and effectiveness necessitate a more thorough modification of transportation equipment and working places from an ergonomic point of view.

4. Standardization

The trend towards standardization is in no way as strong as could be desired. It is most noticeable in questions of modification of unit loads, figuring of packages, demands for continuous units through several transport links and also in changes to container transport.

5. Centralization

A trend towards centralization which consequently entails greater production units and specialization is due among other things to:

- better possibilities of external transports
- greater improvement of administrative routines with the help of computer
- greater possibilities of mechanization and automatization
- possibilities to utilize industrial management in a better way.

6. Utilization of computer

Larger units, higher complexity, increased demands for speed and safety in information together with a very fast development in computer techniques concerning both software and hardware have resulted in this technique being used to a great extent for guiding and checking material flow in industry.

7. Increased co-operation

Because of increased industrialization a need for more industrial contacts can arise in the future in order to improve methods of buying raw materials, components, equipment etc of high quality.

10. REFERENCES

Ackoff, Russell L. Scientific Method: Optimizing Applied Research Decisions. - New York. John Wiley and Sons. 1968.

Apple, James M. Plant Layout and Materials Handling. - Ronald press Company. New York. 1963.

- . Lesson Guide Outline on Material Handling Education. - Pittsburgh. 1965.

- . The systems concept in material handling. - Industrial Eng. - Atlanta, USA. Jan 1973.

- . Plant Layout and Materials Handling. - Ronald Press Company. New York. 1977.

Bjerner, Sigfrid. Transportteknisk utveckling. Allmänna grundsatser och riktlinjer. - Utg. 4. Institutionen för transportteknik. Lund 1981.

- . Transportteknik. Transportplanering, materialhantering och transportörer. - Inst för transportteknik. Lund 1982.

Booth, K E and Chantrill, C G. Materials handling with industrial trucks. - British Industrial Truck Association. London 1962.

Harrison, T M. Is job handling really different? - Canadian Machinery and Metalworking, Kanada Oct. 1972. pp 58-59, 90.

- . Basic principles for flexible, efficient handling. - Automation, USA July 1972. pp 32-36.

Hernegård, Mats, Ljung, Thomas & Pålsson, Mats. Svensk industrietablering i Spanien: Bestämningsfaktorer vid utformning av produktionssystem - Inst för industriell organisation. Lund 1977.

Larsson, Everth. Studieresa till franska företag och institutioner med anknytning till forskningsprojektet: Interna transportsystems optimering vid olika grader av automatisering. - Inst för transportteknik. Lund 1971.

Larsson, E & Magnusson, L. Besök av prof James M Apple, Georgia Institute of Technology, för överläggningar om forskningsprojekt. - Inst för transportteknik. Lund 1971.

Larsson, Everth. Forskningsprojekt: Interna transportsystems optimering vid olika grader av automatisering. Studieresa till England. - Inst för transportteknik. Lund 1972.

- . Planering och optimering av transportsystem inom varuproducerande företag. - Inst för transportteknik. Lund 1973.

Lundqvist, Nils, Magnusson, Lennart & Olsson, Göte. Systematisk transportanalys. - Inst för transportteknik. Lund 1973.

Lundqvist, Nils. Simulering vid planering av fysiska lagrings-system. - Inst för transportteknik. Lund 1974.

Magee, John F. Physical distribution systems. - USA 1967.

Maniatis, Paraschos. Investigation of the Materials Handling System in a Greek Tannery. - Transportation and Materials Handling Eng. Dept. Lund 1981.

- . A literature study of Materials Handling Analysis and Layout Planning. - Transportation and Materials Handling Eng. Dept. Lund 1982.

- . Planning Materials Handling Systems in Greek Industries. Important factors. - Transportation and Materials Handling Eng. Dept. Lund 1982.

Muther, Richard. Systematic Layout Planning. - C B I Publishing Co. 1973.

Muther, Richard & Haganäs, Knut. Systematic Handling Analysis. - Managment and Industrial Research Publ. Kansas City 1969.

Muther, Richard & Hales, Lee. Systematic Planning of Industrial Facilities. - S.P.I.F. - Managment and Industrial Research Publ. 1979.

Olsson, Göte & Ulveland, Peter. Förflyttning av basobjekt mellan monteringsstationer. - Inst för transportteknik. Lund 1976.

Olsson, Göte. Administration av interna fordonstransporter vid tung industri. - Inst för transportteknik. Lund 1977.

Schön, Lennart. Förutsättningar för industrialismen. - Lunds universitet. Ekonomisk-historiska inst. Lund 1981.

Skinner, Wickham. American Industry in Developing Economies. - John Wiley & Sons, Inc. New York 1968.

Solo, Robert A. Economic Organizations & Social Systems. - The Bobbs-Marrill Company, Inc. USA 1967.

Statistical Yearbook of Greece. - National Statistical Service of Greece. Athens 1981.

Turner, Waynec. How best to save energy in materials handling. - Modern materials handling, nr 9, 1980. pp 94-99.

Wells, G L. Process Engineering with Economic Objective. - Billing & Sons Limited, Great Britain 1973.

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